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# Lower Missouri River Basin
# Draft Environmental Impact Statement

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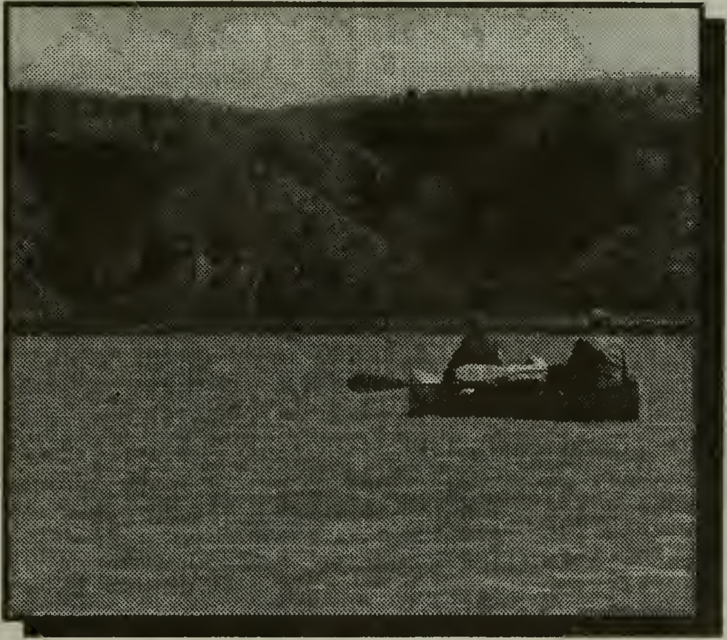

## Water Reservation Applications For The Missouri River and Its Tributaries Below Fort Peck Dam

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# ABBREVIATIONS

af — acre-feet
af/yr — acre-feet per year
APA — Administrative Procedure Act
ARM — Administrative Rules of Montana
BHES — Montana Board of Health and Environmental Sciences
BLM — United States Bureau of Land Management
Board — Montana Board of Natural Resources and Conservation
BUREC — United States Bureau of Reclamation
cfs — cubic feet per second
Corps — United States Army Corps of Engineers
CRP — Conservation Reserve Program
DFWP — Montana Department of Fish, Wildlife and Parks
DHES — Montana Department of Health and Environmental Sciences
DNRC — Montana Department of Natural Resources and Conservation
DO — dissolved oxygen
EIS — environmental impact statement
EPA — United States Environmental Protection Agency
FAO — United Nations Food and Agriculture Organization
gpd/ft — gallon per day per foot
gpm — gallon per minute
GWh — gigawatt hour
HB — House bill
JTU — Jackson turbidity unit
kWh — kilowatt-hour
MBMG — Montana Bureau of Mines and Geology
MCA — Montana Code Annotated
MEPA — Montana Environmental Policy Act
mg/l — milligrams per liter
MNHP — Montana Natural Heritage Program
MPC — Montana Power Company
MW — megawatt
MWh — megawatt-hour
N — nitrogen
NDSWC — North Dakota State Water Commission
$NO_3$-N — nitrate-nitrogen
NTU — nephelometric turbidity unit
P — phosphorous
RGE — range
SAR — sodium absorption ratio
SCS — United States Soil Conservation Service
SEC — section
SHPO — Montana Historical Society, State Historic Preservation Office
TDS — total dissolved solids
TSS — total suspended solids
TWN — township
ug/l — micrograms per liter
USDA — United States Department of Agriculture
USFS — United States Forest Service
USFWS — United States Fish and Wildlife Service
USGS — United States Geological Survey
UT — unnamed tributary
WETP — wetted perimeter inflection point
yr — year

# LOWER MISSOURI RIVER BASIN

# DRAFT ENVIRONMENTAL IMPACT STATEMENT

## FOR WATER RESERVATION APPLICATIONS BELOW FORT PECK DAM

DNRC

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

FEBRUARY 1994

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION

MARC RACICOT, GOVERNOR

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STATE OF MONTANA

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HELENA, MONTANA 59620-2301

# NOTICE - FEBRUARY 28, 1994

The Department of Natural Resources and Conservation (DNRC) recently completed its draft environmental impact statement (EIS) on proposed reservations of water in the Missouri River Basin below Fort Peck Dam. Reservations of water are sought by the following public agencies:

Conservation Districts:

- Blaine County
- Carter County
- Daniels County
- Liberty County
- Little Beaver
- McCone
- Richland County
- Roosevelt
- Sheridan County
- Valley County
- Wibaux

Municipalities and Water Districts:

- Chinook
- Circle
- Culbertson
- Ekalaka
- Fort Peck
- Harlem
- Havre
- Hill County Water District
- Malta
- Plentywood
- Poplar
- Scobey
- Wibaux
- Wolf Point

State Agencies:

Montana Department of Fish,
Wildlife and Parks

Copies of this EIS are being circulated for public review and comment for 45 days, ending April 14, 1994. Persons making written comments should address comments to:

Missouri River Reservations
Department of Natural Resources
and Conservation
1520 East Sixth Avenue
P.O. Box 202301
Helena, MT 59620-2301

Public meetings on the EIS will be held in five lower Missouri basin communities. DNRC employees will be available prior to the public meetings to answer questions on the reservation process and Draft EIS. The public meetings will begin at 7:00 p.m. to take comments on the EIS.

| Where | Location | Date | Times | |
|---|---|---|---|---|
| | | | EIS Information | Public Meeting |
| Baker | Baker High School | 3/21/94 | 5:30-7:00 | 7:00-10:00 |
| Glasgow | Cottonwood Inn | 3/22/94 | 5:30-7:00 | 7:00-10:00 |
| Havre | Northern Montana College, Student Union Building, Crowley Conference Room | 3/22/94 | 5:30-7:00 | 7:00-10:00 |
| Plentywood | Courthouse - Public Library Meeting Room | 3/23/94 | 5:30-7:00 | 7:00-10:00 |
| Wolf Point | Wolf Point High School Auditorium | 3/24/94 | 5:30-7:00 | 7:00-10:00 |

The lower Missouri River Basin Draft Environmental Impact Statement for Water Reservation Applications below Fort Peck Dam and this notice were prepared pursuant to the Montana Environmental Policy Act and the Montana Water Use Act. Copies of this EIS and this notice were filed with the Governor and the Environmental Quality Council on February 28, 1994. For more information or to request accommodation for a disability, please contact Larry Dolan at (406) 444-6627 (TDD 444-6873) as soon as possible before the scheduled date. Additional copies of this EIS can be obtained by calling (406) 444-6627, or by writing to DNRC at the address listed above.

Mark A. Simonich

Mark A. Simonich, Director
Department of Natural Resources
and Conservation

# SUMMARY

## MISSOURI RIVER WATER RESERVATION STATUTE

In 1985, the Montana Legislature directed the Montana Department of Natural Resources and Conservation (DNRC) to begin a water reservation proceeding for the Missouri River basin. In subsequent sessions, the legislature directed DNRC to add the Little Missouri River drainage to the proceeding. The legislature felt that implementation of a water reservation procedure would encourage more coordinated development of the water resources in the basin and would help form a strong and unified basis for protecting Montana's share of the Missouri River water from downstream states.

Under Montana water law, water can be reserved for existing or future consumptive uses of water and for maintaining instream flows to protect aquatic life, recreation, and water quality. Only public entities such as local governments, conservation districts, and state and federal agencies can apply for and hold water reservations. DNRC was assigned by statute to coordinate the process and to provide technical and financial assistance to conservation districts and municipalities in preparing their applications.

Due to the vast size of this basin, the Missouri River reservation proceeding has been split into two parts. Applications for water in the upper portion of the basin, which encompasses the drainage area upstream from Fort Peck Dam, were considered first. After an environmental review and contested case hearing, the Board of Natural Resources and Conservation (Board) made a final decision on the upper basin applications in June 1992. DNRC then began preparation of this draft environmental impact statement (EIS) for the lower basin reservation application. The Board must reach a decision on water reservation applications in the Missouri River basin below Fort Peck Dam (including the Milk and Little Missouri River basins) by December 31, 1994.

## APPLICATIONS

DNRC received 26 reservation applications for water in the lower basin. Fourteen municipalities applied for 46,167 acre-feet a year to meet future growth. Eleven conservation districts requested 276,407 acre-feet a year primarily for 471 proposed irrigation projects covering 157,994 acres. The Montana Department of Fish, Wildlife and Parks (DFWP) applied to reserve instream flows on 21 streams or stream reaches to protect fish, wildlife, recreation, and water quality.

## EIS PROCESS

The Montana Environmental Policy Act (MEPA) requires preparation of an EIS for major state government actions that have the potential to significantly affect the human and natural environment. This EIS examines the environmental, social, and economic impacts of the proposed requests. DNRC held public meetings in five towns throughout the basin to identify important issues for analyses and inclusion in the EIS. DNRC developed a computer model of the Missouri River basin to assess physical and legal availability of water. This draft EIS is based on the above information and research and analysis by DNRC staff and consultants. Following release of the draft EIS, there will be a 60-day period for interested parties to comment on the draft EIS. DNRC also will hold public meetings across the basin to receive comments on the draft EIS. The final EIS will address all substantive comments on the draft EIS.

## ALTERNATIVES

To address the full range of options available to the Board and potential impacts, DNRC selected several alternatives to analyze in the EIS. They are: the Consumptive Use, Instream, Combination, and No Action alternatives. In Sheridan County, where extensive groundwater development is proposed, three different alternatives were analyzed: the Grant All, Partial Granting, and Coordinated Groundwater Development alternatives.

Municipalities were included under all but the No Action Alternative and given first priority because of the relatively small amount of water requested for their purposes and the high value of water for municipal use.

The Consumptive Use Alternative emphasizes the use of water for irrigation and municipal purposes. First priority in this alternative goes to municipalities, followed by proposed irrigation projects, and then instream uses. All irrigation projects proposed in the reservation applications were included in this alternative.

The Instream Alternative gives first priority to municipal uses, but emphasizes instream reservations for the protection of fish, wildlife, recreation, and water quality. Some irrigation reservation requests were included in this alternative, but with third priority.

To some extent, the Combination Alternative is similar to the Consumptive Use Alternative in that it gives first preference to municipalities, second to proposed irrigation projects, and third to instream uses. It differs primarily in that proposed irrigation projects are only included if they are at least marginally economically and financially feasible at least 50 percent of the time.

In Sheridan County, the City of Plentywood would have first priority under all but the No Action Alternative. The Grant All Alternative would allow the Sheridan County Conservation District to use all the water it requested in compliance with the district's reservation management plan. Under the Partial Granting Alternative, the Board would grant the Sheridan County Conservation District a reservation for the amount of water DNRC believes the Westby-Dagmar and associated aquifers can sustain (7,809 af/yr) without adverse effects to existing water right holders and wetlands. The Coordinated Groundwater Development Alternative would allow a larger reservation of 17,470 af/yr—the maximum amount that DNRC believes the aquifers might sustain. The alternative is conditioned on the creation of a controlled groundwater area. Groundwater commissioners would be appointed by DNRC and would include area water users, the conservation district, USFWS, the Sheridan County Planning Department, an existing water user, Ducks Unlimited, and a DNRC hydrogeologist. The commissioners would oversee implementation of the reservation.

Under the No Action Alternative, DNRC describes trends that might unfold through the year 2035 if no water is reserved for any purpose.

## BOARD'S AUTHORITY

The Board can grant, modify, or deny any or all of the reservation requests. Applicants must establish to the satisfaction of the Board the following four criteria:

a. the purpose of the reservation;
b. the need for the reservation;
c. the amount of water necessary for the reservation; and
d. that the reservation is in the public interest.

Besides these criteria, the Board also must ensure that the reservation applicants make progress toward development of the proposed use with reasonable diligence and that no reservations are granted that would adversely affect senior water rights. The Board will have to base its decision on the decision criteria described in Chapter Seven and rely on information in the applications, draft and final EIS, and on testimony presented at the contested case hearing.

## IMPACTS UNDER THE ALTERNATIVES

### GENERAL CONSIDERATIONS

Environmental impacts are generally greatest under the Consumptive Use Alternative, less under the Combination Alternative, and least under the Instream Alternative. In the Sheridan County Groundwater Area, impacts would be greatest under the Grant All Alternative and less under the Partial Granting and Coordinated Groundwater Development alternatives. Some proposed projects included in all but the No Action Alternative would have substantial impacts. Not all potential impacts were assessed for some of the larger projects, where information was not required or available in the applications. A separate environmental review may be required before larger projects such as CBI-13 or the Battle Creek Reservoir (project BL-181) could be constructed.

### WATER QUANTITY AND DISTRIBUTION

Impacts to streamflows would be greatest under the Consumptive Use Alternative, which would reduce flows slightly in the Milk and Missouri rivers, and moderately to substantially in the Poplar and Little Missouri River drainages. In several of these rivers and streams, late summer streamflows would be reduced to zero or near zero during dry years. Impacts to streamflows would be less under the Combination Alternative and least under the Instream Alternative.

## GROUNDWATER

In the Sheridan County Groundwater Area, the amount of water applied for in the Grant All Alternative (113,587 af/yr) greatly exceeds any estimate of groundwater available for sustainable use. The impacts of this alternative would depend on how much water the Sheridan County Conservation District develops. The Westby-Dagmar aquifer might yield as much as 50,000 af/yr without affecting senior water rights for other wells. However, this would cause a drastic alteration in the hydrology of the aquifer. Aquifer water levels would decline and lakes and wetlands connected to the aquifer would decrease in size and eventually be eliminated.

Under the Partial Granting Alternative, major changes in the hydrology of the aquifer would be less likely because of the limited amount of water granted. However, this alternative does not effectively "tie up" all available groundwater in the area, which might limit the ability of the Sheridan County Conservation District to manage groundwater withdrawals.

Under the Coordinated Groundwater Development Alternative, the maximum estimated sustainable yield of the aquifers would be granted and a controlled groundwater area would be established. The Sheridan County Conservation District would gain the right to the groundwater, while a local board overseeing the controlled groundwater area would have a hand in determining the sustainable level of development.

## LEGAL WATER AVAILABILITY

By law, water reservations cannot adversely affect the amount of water legally available to holders of water rights with a priority date earlier than July 1, 1985, in the Milk and Missouri River drainages and July 1, 1989, in the Little Missouri River drainage. However, if an existing water right user wishes to change the point of diversion, place of use, purpose of use, or place of storage, all senior and junior water right holders, including those with water reservations, have a right to object to the change if they feel that the exercise of their water rights would be adversely affected. This same legal right allows holders of water reservations to object to water right claims submitted in the statewide adjudication proceeding. Holders of water reservations, like all other water right holders, may seek relief from the district court to protect their water rights.

While water may be physically available for a reservation at the point of diversion, it may already be appropriated by a water user downstream. Existing water users such as irrigators and Indian tribes already claim much of the flow in many of the Missouri River tributaries. During the contested case hearing, it will be determined if reservations will adversely affect the use of senior water rights.

## WATER QUALITY

Water reservations for consumptive use would cause a decline in water quality in some streams and groundwater systems. Higher concentrations of nutrients, pesticides, sediments, and salts would be noticeable in some waters, but in most instances the increases would be minor. Short-term increases in sediments would result from construction of reservoirs and diversion structures.

Arsenic originating in geothermal areas of Yellowstone Park persists in reduced concentrations in the lower Missouri River. Sufficient information is not available to determine whether new irrigation development with water containing arsenic would cause local and downstream surface water to increase in arsenic concentration and violate the state's ambient water quality standard.

In the Milk River subbasin, the cumulative effect of Battle Creek projects on water quality in the Milk River would be small. Streamflow of the Milk River near Harlem would be reduced by about 1 percent in median flow years if the Montana projects were developed.

The Poplar River contributes about 1.3 percent of the average annual streamflow and chemical load of the Missouri River near Culbertson (less in dry years). Because of this, the effects of consumptive use of Poplar River water on the Missouri River are small. Groundwater development in Sheridan County would similarly have a small effect on water quality in the Missouri River.

Within the Little Missouri subbasin, consumptive flow depletion in dry years would increase total dissolved solids and sodium adsorption ratios, and irrigation development would require careful application of water and special management to minimize decline in soil productivity and crop yields. Reduction in summer streamflow would increase the frequency of no flow and could raise water temperatures, lower dissolved oxygen, and thereby harm aquatic life.

## SOILS

In general, reservations that would result in the conversion of riparian areas or rangeland to irrigated cropland would affect soils through the loss of organic matter, reduced water-holding capacity, and increased susceptibility to erosion. These effects would be somewhat offset once an alfalfa crop is established. Where reservations convert dry cropland to irrigation, soil structure will improve, wind and water erosion will decrease, and nitrogen and organic fertility will increase. Projects that might have substantial adverse soil impacts are identified in Chapter Six. Other effects of consumptive use projects on soils are generally minor.

## STREAM CHANNEL FORM

Impacts to stream channels generally would be minor. In some instances, consumptive water uses could decrease channel capacity by increasing the deposition of sediment. Instream reservations would not change existing stream channel forms. By trapping sediment and altering flow patterns, the proposed Battle Creek dam project (BL-181) could substantially alter stream channel characteristics in Battle Creek downstream.

## VEGETATION

Impacts to vegetation would result from replacement of natural plant communities with agricultural crops, inundation of riparian and upland plant communities by reservoirs, reduced streamflows, lowered water tables, and increased proliferation of noxious weeds. Substantial losses to riparian vegetation would occur along the lower Missouri River under the Combination Alternative, where up to 8,956 acres would be lost, and Consumptive Use Alternative, where up to 8,404 acres would be lost. Wetlands near the Missouri River also would be lost under the Consumptive Use and Combination alternatives. The potential for loss of wetlands in the Sheridan County Groundwater Area due to lower water tables is a substantial concern under the Grant All Alternative.

## LAND USE

Proposed irrigation reservations would convert nonirrigated cropland, pasture, and rangeland to irrigated fields. Reservations would allow newly irrigated cropland to increase in the basin by about 22 percent (57,387 acres) under the Consumptive Use Alternative, 12 percent (32,106 acres) under the Combination Alternative, and 3 percent (7,363 acres) under the Instream Alternative. In the Sheridan County Groundwater Area, irrigated land could increase by 540 percent (42,600 acres) under the Grant All Alternative, 32 percent (2,400 acres) under the Partial Granting Alternative, and 70 percent (5,500 acres) under the Coordinated Groundwater Development Alternative. Thirty-seven irrigation projects may have other substantial land use impacts, caused by pipelines, canals, and transmission lines. These are identified in Chapter Six. Other land use impacts are generally minor.

## FISH AND AQUATIC HABITAT

Low flow conditions already stress gamefish populations and aquatic habitat on some rivers and streams in the basin. Further consumptive uses would generally worsen conditions on these rivers and streams. Streams most severely affected by the proposed consumptive use reservations under the Consumptive Use Alternative include the Poplar River and East Fork Poplar River, Little Missouri River, Boxelder Creek, and Little Beaver Creek. Under the Grant All Alternative in the Sheridan County Groundwater Area, aquatic habitat could be reduced in Big Muddy Creek.

Streams where the effects could be less include the Missouri River and smaller ephemeral tributary streams. Stored water might be released from Fort Peck Reservoir to offset most water depletions in the lower Missouri River. Reservations for instream flows would help maintain the existing aquatic habitat and fisheries. It is unlikely that the proposed irrigation storage projects could support a fishery. On large irrigation projects, fish could be killed in the diversion structures, though this could be minimized through proper design.

Construction and operation of Fort Peck Dam have greatly modified habitat of pallid sturgeon, a federally listed endangered species that inhabits the Missouri River. The effects of proposed flow reductions would reduce habitat of the pallid sturgeon slightly. These reductions would be in addition to existing impacts caused by the dam.

## WILDLIFE

Wildlife habitat would be reduced by conversion of native vegetation to cropland as described under the vegetation section. Draining of wetlands and lakes would reduce the amount of habitat available to waterfowl and shorebirds. Least terns, a federally listed endangered species, are found along the lower Missouri River, and piping plovers, a listed threatened species, are found along the lower Missouri River and beside saline lakes and ponds in the Sheridan County Groundwater Area. Reductions of flow or lowering of water tables could make these species and other waterfowl more vulnerable to predation, although such effects have not been quantified.

Farming operations could disturb nesting raptors, and cultivation could destroy grouse courtship and breeding areas. However, in most cases, site-specific information is not available to determine the extent of the effect, if any.

Adverse effects to wildlife habitat would be greatest under the Consumptive Use Alternative, where 4,100 acres of native woodland (mostly riparian cottonwood habitat) and scrub/shrub habitats, and 4,800 acres of native prairie and mixed prairie habitats would be cultivated along the lower Missouri River. Impacts would be lower under the Combination Alternative and slight under the Instream Alternative. In the Sheridan County Groundwater Area, water tables could be lowered the most and have the greatest effect under the Grant All Alternative and least under the Coordinated Groundwater Development Alternative.

In the Sheridan County Groundwater Area, habitat of the piping plover, a federally listed threatened species, could be affected by a lowering of water tables in wetlands used by these birds. Along the lower Missouri River, some projects are near areas known to be used by least terns or piping plovers and their nesting could be disturbed during project construction.

## HISTORICAL, ARCHAEOLOGICAL, AND PALEONTOLOGICAL SITES

Proposed consumptive use reservations could affect up to 31 known historical or archaeological sites, although a small number of these are likely to contain information important to interpreting the past. No known paleontological sites would be affected. There is a moderate potential for discovery of historical, archaeological, and paleontological sites, particularly where projects would be developed on undisturbed rangeland. Most sites are located on private land where formal evaluation is not required to determine if the sites might be eligible for listing on the National Register of Historic Places, unless the Board would choose to do so as part of its approval of reservations.

## STORAGE

Reservations may reduce water available for future storage projects. Existing water rights could be a greater constraint to the development of new storage than water reservations. The reservation applications include five water storage projects. Together, they could store up to 20,239 af/yr of water.

## RECREATION

Instream reservations would help maintain streamflows on streams and rivers that are important to recreation. The small flow reductions that would occur in the Missouri River below Fort Peck Dam under any of the alternatives would have minor effects on recreation opportunities.

Flow increases resulting from the Virgelle project in the Milk River above Dodson during summer under all three alternatives might improve fishing and floating opportunities. If the Virgelle Diversion project is not constructed, fishing and floating opportunities in the Milk River would decrease slightly.

Under the Consumptive Use Alternative, dam operations on the Battle Creek project could improve stream fishing opportunities if habitat is improved and fish populations increase. New fishing or boating opportunities on the reservoir for Battle Creek Dam would be marginal due to repeated reservoir drawdowns for irrigation.

For the Poplar River, East Fork of the Poplar River, and prairie streams that support fish in the Little Missouri River drainage, already marginal fishing opportunities would decrease further under the Consumptive Use and Combination alternatives.

Possible effects at Medicine Lake National Wildlife Refuge from proposed pumping in the Sheridan County Groundwater Area include decreasing and changing locations available for wildlife observation and photography. Decreased water levels could further limit fishing opportunities in Big Muddy Creek and Medicine Lake.

Instream flow values for the middle Missouri and Marias/Teton subbasins (Duffield 1990) were used as approximate recreation values of an acre-foot of flow on rivers and streams in the lower Missouri River basin study area. These values were $5.81 per acre-foot for July and August flows and $1.63 per acre-foot for flows during the rest of the year. The annual value of recreation losses (the recreational value per acre-foot of flow multiplied by estimated changes in average streamflow for each alternative due to proposed reservations) is estimated to be $337,201 under the Consumptive Use Alternative, $191,454 under the Combination Alternative, and $16,968 under the Instream Alternative. The annual value of recreation losses could not be estimated in Sheridan County.

### HYDROPOWER

Consumptive use reservations eventually would increase the cost of electricity to ratepayers. They would do this by: (1) decreasing streamflows that are used to generate electricity in downstream states; and (2) requiring production of additional electricity. These two actions would require production of replacement power that would be considerably more expensive than power from existing supplies. The total monetary impact to ratepayers would range from $2.18 million to $5.60 million a year under the Consumptive Use Alternative, $1.20 million to $3.00 million a year under the Combination Alternative, and $0.13 million to $0.38 million a year under the Instream Alternative. Impacts to ratepayers because of reduced hydroelectric generation could not be estimated for projects in Sheridan County. The impacts to ratepayers because of increased electric power use from proposed projects in Sheridan County would range from $0.19 million to $1.14 million a year under the Grant All Alternative; $0.01 million to $0.05 million a year under the Partial Granting Alternative; and $0.02 million to $0.13 million a year under the Coordinated Groundwater Development Alternative.

### AGRICULTURE

Development of irrigation projects in the basin under any alternative would have small beneficial effects on jobs, personal income, taxes, and agricultural sales. About 12 jobs would be created among the four subbasins under the Instream Alternative and about 100 under the Consumptive Use Alternative. Benefits would be greatest in the Sheridan County Groundwater Area where, if all projects could be developed, 56 jobs might be created. Personal income in the basin would increase between $0.02 million a year under the Instream Alternative and $1.6 million a year under the Consumptive Use Alternative. County tax receipts would increase between $58,000 a year under the Instream Alternative and $151,000 a year under the Consumptive Use Alternative. Agricultural sales would increase between 0.5 percent under the Instream Alternative and 4.2 percent under the Consumptive Use Alternative.

### SOCIAL EFFECTS

The reservations would not noticeably change the social character of communities in the Missouri River basin.

## NO ACTION ALTERNATIVE

If the Board were to deny all reservation applications, consumptive water users could still apply through the water use permitting process to appropriate water for beneficial uses. A potential user also might be able to purchase water from tribes of the Fort Peck Indian Reservation or from existing water right holders. Municipalities could condemn existing water rights to meet needs when they occur in the future.

Some new irrigation projects would be built in the basin. However, the total acreage of irrigated land might remain stable as lower quality irrigated land goes out of production because of low crop prices and higher yields on good land.

If instream reservations are not granted, instream flows in many streams and rivers would not be protected by a water right. In some instances, increased consumptive uses could lead to streams becoming very low or going dry, resulting in adverse impacts to water quality, aquatic life, recreation, and wildlife. Tribal water rights and federal and state water quality standards for arsenic could provide some level of instream flow protection in some streams and rivers.

If present trends hold, few large storage projects will be built over the next 25 years. Emphasis during this period probably will be on rehabilitation and enlargement of existing facilities as defined in the state water plan.

### OTHER REASONABLY FORESEEABLE ACTIONS

The U.S. Army Corps of Engineers is currently reviewing its master manual, which governs releases of water from Fort Peck and the system of downstream reservoirs it operates. The outcome of this review is not known, but could change flow patterns in the lower Missouri River. A draft EIS on this review is expected to be released in May of 1994. If additional information regarding the Master Manual review becomes available, it will be provided to the Board in the final EIS.

USFWS has issued a recovery plan for endangered pallid sturgeon inhabiting the lower Missouri River. This plan calls for a more natural flow pattern in the river. It is not known what effect this will have on releases from Fort Peck Reservoir.

Canada is entitled to a substantial portion of the Milk River and half the flow of Milk River tributaries originating in Canada. If Canadians use the water they are entitled to and all requested reservations are granted, flows in the Milk River could be substantially reduced, and flows in the lower Missouri River would be reduced slightly. Shortages of water for irrigation along the Milk River would increase, and some irrigated land might go out of production. Impacts to water quality, aquatic habitat, and water-based recreation also would increase.

If the Virgelle Diversion—approved during the upper basin reservation proceeding—is not constructed and Canadian and Indian water entitlements are fully developed in the future, a significant reduction in flow of the Milk River would occur. Under these conditions, chemical concentrations (salinity) of the Milk River would increase to the point that water is unsuited for irrigation use. Physical water quality may further decline with increases in temperature and turbidity and a reduction in dissolved oxygen. Concentrations of cadmium, iron, lead, and manganese in the Milk River at Nashua would approach or exceed the public drinking water standard more frequently.

Under the Fort Peck Compact between the tribes of the Fort Peck Indian Reservation and the State of Montana, the tribes may use up to 50,000 af/yr of water from the Missouri River. The majority of this water would be used during the summer, but it is uncertain how the water would be used or where it would be diverted. The cumulative effects on the lower Missouri River from the proposed reservations and the Fort Peck Compact might be reductions in flow, water quality, aquatic habitat, and recreational opportunities. Any such impacts would be in addition to those caused by state water reservations. These changes cannot be reasonably quantified at this time.

Reductions in streamflow due to the combined use by the Canadians, tribes of the Fort Peck Indian Reservation, and state water reservations could cause total dissolved solids and trace-element concentrations in the Missouri River to frequently exceed water quality standards and criteria for public drinking water, and might limit the suitability of the water for irrigation. Flow reductions probably would be accompanied by thermal increases and reduced dissolved oxygen concentrations harmful to aquatic life.

## BOARD DECISION CRITERIA

The decision of whether to grant, modify, or deny the reservation applications rests with the Board, which must abide by several criteria that are discussed below. The ability of the requested reservations to meet these criteria is examined in DNRC's research and analyses of the reservation applications, as explained in Chapter Seven. These results are preliminary and do not represent conclusions on whether any reservation request satisfies any of these criteria. Such determinations are made by the Board.

### QUALIFICATION AND PURPOSE

The Board must determine (a) that of those who applied for reservations, all are qualified to reserve water through the Missouri River basin water reservation proceeding; and (b) the stated purposes for all reservations requested are beneficial uses under Montana law.

### NEED

The regulation states that a water reservation is needed if "there is a reasonable likelihood that future instate or out-of-state competing water users would consume, degrade, or otherwise affect the water available for the purpose of the reservations," or if "there are constraints that would restrict the applicant from perfecting a water permit for the intended purpose of the reservation." All applicants identified a purported need to reserve water. Conservation districts want to secure water for agricultural production before the water is appropriated by other users in Montana or by downstream states. They also want to have the option to develop this water when the economic climate improves. Municipalities want to appropriate water to meet future growth when available water supplies are diminishing in the basin. DFWP wants secure instream flows to protect fish, wildlife, recreation, and water quality.

## AMOUNT

The Board must determine the amount needed to fulfill the purpose of the reservations. This amount must be based on accurate and suitable measuring methods and determinations that no reasonable cost-effective measures could be taken within the reservation term to increase efficiency and lessen the amount of water required.

Conservation districts' requests are based on recorded crop requirements and efficiency of proposed irrigation systems. Many of the projects were designed for efficient sprinkler irrigation.

Municipalities requested enough water to service population growth to the year 2035. Increased population multiplied by per capita rate of consumption was used to calculate the total amount requested in the applications. Per capita rates were based on actual use requirements for each community. Population projections based on the 1990 census indicate that population growth and the associated amounts of water requested by 14 of the municipalities may be higher than expected to occur.

DFWP used several methods to determine its instream flow reservation requests. These methods are summarized in Appendix C.

## PUBLIC INTEREST

Reservations for municipal water supplies and irrigation would provide monetary benefits to basin communities. However, they would decrease streamflows which could adversely affect recreation and hydropower production. Reservations for consumptive uses also would use additional power, which would eventually require the production of higher cost electricity. The value of an acre-foot of water for instream flow is based on recreation and electricity production. Table S-1 identifies the total benefits and costs of water uses under the three alternatives. Excluding the Sheridan County Groundwater Area, net benefits per year are greatest under the Instream Alternative ($37.80 million), less under the Combination Alternative ($31.13 million), and considerably lower under the Consumptive Use Alternative ($12.48 million). Benefits and costs to recreation and hydropower production could not be estimated in the Sheridan County Groundwater Area.

Municipal water developments have benefits that exceed costs by $37.79 million because of the small amount of water consumed and the high value of this use under all three alternatives (Table S-2). This assumes that the proposed water use is actually needed by the municipalities. In contrast, proposed irrigation projects would consume large amounts of water. Total costs associated with the depletions would exceed total benefits by $25.31 million a year under the Consumptive Use Alternative and $6.67 million a year under the Combination Alternative. However, total benefits exceed total costs by $0.01 million a year under the Instream Alternative (Table S-2).

The value of an acre-foot of water for instream and consumptive uses can be compared when there is only enough water for one type of use. Outside of the Sheridan County projects, 54 proposed irrigation projects would value an acre-foot of water at a greater level than the instream values, and 109 proposed irrigation projects would value water less than the instream values. This assumes a 5 cents/kWh cost for replacement power and a 10-year-in-10 water availability. The value of an acre-foot of water for all municipal reservations exceeds the value of water for instream flow and proposed irrigation projects.

On each stream or stream reach, the number of requests that will give the greatest net benefit is based, in part, on the amount of water available. However, water availability may not be definitely known before the Board acts on the reservation requests.

**Table S-1. Benefits and costs of water use under six alternatives ($ million)[a]**

| | Consumptive Use | Combination | Instream | GAA | PGA | CGDA |
|---|---|---|---|---|---|---|
| Irrigation | 25.69 | 20.82 | 1.60 | 23.88 | 2.07 | 3.85 |
| Municipal | 39.96 | 39.96 | 39.96 | 3.67 | 3.67 | 3.67 |
| Recreation | -7.04 | -4.00 | -0.35 | unk | unk | unk |
| Hydropower production | -39.05 | -21.94 | -2.21 | unk | unk | unk |
| Replacement power | -6.48 | -3.12 | -0.60 | -3.96 | -0.18 | -0.47 |
| Total | 12.48 | 31.13 | 37.80 | 23.59 | 5.56 | 7.06 |

GAA = Grant All Alternative, PGA - Partial Granting Alternative,
CGDA = Coordinated Groundwater Development Alternative (only for Sheridan County)

[a] Positive numbers represent net benefits, and negative numbers represent net costs. All figures are the value today of 70 years of future impacts based on a 4.6 percent real discount rate.

**Table S-2. Benefits and costs of reservations for irrigation and municipal uses ($ million)[a]**

| | Consumptive Use | Combination | Instream | GAA | PGA | CGDA |
|---|---|---|---|---|---|---|
| Irrigation | | | | | | |
| benefits | 25.69 | 20.82 | 1.60 | 23.88 | 2.07 | 3.85 |
| costs | -51.00 | -27.49 | -1.59 | unk | unk | unk |
| net | -25.31 | -6.67 | 0.01 | unk | unk | unk |
| Municipal | | | | | | |
| benefits | 39.36 | 39.96 | 39.36 | 3.67 | 3.67 | 3.67 |
| costs | -1.57 | -1.57 | -1.57 | unk | unk | unk |
| net | 37.79 | 37.79 | 37.79 | unk | unk | unk |

GAA = Grant All Alternative, PGA = Partial Granting Alternative,
CGDA = Coordinated Groundwater Development Alternative (only for Sheridan County)

[a] Positive numbers represent net benefits, and negative numbers represent net costs. All figures are the value today of 70 years of future impacts based on a 4.6 percent real discount rate.

# CONTENTS

GLOSSARY . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . XI

CHAPTER ONE: INTRODUCTION . . . . . . . . . . . . . . . . . . . . . . . 1
EIS PROCESS . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 1
CONTESTED CASE HEARING . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
WHO HAS APPLIED . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
AGENCIES WITH ADDITIONAL PERMITTING AUTHORITY . . . . . . . . . . . . . . . . . . . 2

CHAPTER TWO: MONTANA WATER LAW . . . . . . . . . . . . . . . . . . 3
INTRODUCTION . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3
STATE WATER RIGHTS . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3
Existing Rights . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3
Permits . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3
Water Reservations . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4
Federal Reserved Rights . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5
WATER LEASING FOR INSTREAM FLOWS . . . . . . . . . . . . . . . . . . . . . . . . . . . 5
WATER QUALITY REGULATIONS . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5

CHAPTER THREE: DESCRIPTION OF RESERVATION REQUESTS . . . . . . . . . . . . . . . . . . . . . . . . . . 9
CONSERVATION DISTRICT APPLICATIONS . . . . . . . . . . . . . . . . . . . . . . . . . . . 9
Purpose . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9
Need . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9
Determination of Amount . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9
Public Interest . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 20
MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS APPLICATION . . . . . . . . . 20
Purpose . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 20
Need . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 20
Determination of Amount . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 20
Public Interest . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 20
MUNICIPAL APPLICATIONS . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 24
Purpose . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 24
Need . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 24
Determination of Amount . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 24
Public Interest . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 24

CHAPTER FOUR: AFFECTED ENVIRONMENT . . . . . . . . . . . 27
WATER QUANTITY AND DISTRIBUTION . . . . . . . . . . . . . . . . . . . . . . . . . . . . 27
Existing Flow Patterns . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 27
GROUNDWATER . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 32
Introduction to Groundwater in the Basin . . . . . . . . . . . . . . . . . . . . . . . . . . 32
Sheridan County Groundwater Area . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 34

LEGAL WATER AVAILABILITY IN THE LOWER MISSOURI RIVER BASIN ........... 36
  Status of Water Right Claims ........... 36
  Status of Water Right Permits ........... 37
  International Waters ........... 39
  Boundary Waters Treaty ........... 39
  Fort Peck Reservoir ........... 39
  Federal Reserved Rights ........... 39
  Indian Tribes ........... 39
  Federal Agencies ........... 42
WATER STORAGE ........... 42
REVIEW OF MISSOURI RIVER MAIN-STEM OPERATIONS ........... 44
WATER QUALITY ........... 44
  Basinwide Overview of Water Quality ........... 44
  Parameters of Interest ........... 45
SOILS ........... 52
  Lower Missouri River Basin ........... 52
  Milk River Subbasin ........... 52
  Little Missouri River Subbasin ........... 53
  Sheridan County Groundwater Area ........... 53
  Saline Seeps ........... 53
STREAM CHANNEL FORM ........... 54
  Lower Missouri River Basin ........... 54
  Milk River Subbasin ........... 55
  Little Missouri River Subbasin ........... 55
  Sheridan County Groundwater Area ........... 56
VEGETATION ........... 56
  Upland Prairie ........... 56
  Moist Prairie ........... 56
  Breaks ........... 57
  Mountainous Areas ........... 57
  Wooded Draws ........... 57
  Bottomlands ........... 57
  Sensitive Plants ........... 59
  Noxious Weeds ........... 59
  Riparian Land and Wetlands ........... 59
LAND USE ........... 61
  Lower Missouri River Basin ........... 61
FISHERIES AND AQUATIC HABITAT ........... 64
  Threatened and Endangered Species ........... 64
  Species of Special Concern ........... 66
WILDLIFE ........... 70
  Threatened and Endangered Species ........... 70
  Species of Special Concern ........... 72
HISTORICAL, ARCHAEOLOGICAL, AND PALEONTOLOGICAL RESOURCES ........... 74
RECREATION ........... 77
  Patterns of Recreation Participation in Montana ........... 77
  Outfitter Use in the Lower Missouri River Subbasin Study Area ........... 81
SOCIOECONOMICS ........... 83
  Employment ........... 83
  Income ........... 84

- Taxation . . . 84
- Lower Missouri River Basin . . . 86
- Agriculture Economy . . . 86

## CHAPTER FIVE: ALTERNATIVES CONSIDERED IN THIS EIS . 91

- INTRODUCTION . . . 91
- ALTERNATIVES FOR THE LOWER MISSOURI, MILK, AND LITTLE MISSOURI RIVER SUBBASINS . . . 91
  - Consumptive Use Alternative . . . 91
  - Instream Alternative . . . 91
  - Combination Alternative . . . 91
- ALTERNATIVES FOR THE SHERIDAN COUNTY GROUNDWATER AREA . . . 98
  - Grant All Alternative . . . 98
  - Partial Granting Alternative . . . 98
  - Coordinated Groundwater Development Alternative . . . 99
- NO ACTION/DENY ALTERNATIVE . . . 100
- CONSIDERATIONS COMMON TO ALL ALTERNATIVES . . . 100

## CHAPTER SIX: IMPACTS . . . 101

- INTRODUCTION . . . 101
- WATER QUANTITY AND DISTRIBUTION . . . 101
  - Terminology and Concepts . . . 102
- GROUNDWATER . . . 112
  - Sheridan County Groundwater Area . . . 112
- LEGAL WATER AVAILABILITY . . . 122
  - State Water Rights - Claims and Permits . . . 123
  - International Waters . . . 124
  - Federal Reserved Rights . . . 125
- WATER STORAGE . . . 125
  - Impacts . . . 125
- WATER QUALITY . . . 126
  - General Impacts . . . 126
- SOILS . . . 132
  - Soil Impacts Due to Pipeline and Canal Construction . . . 132
  - Impacts of the Consumptive Use, Instream, and Combination Alternatives . . . 134
- STREAM CHANNEL FORM . . . 137
  - General Impacts and Considerations . . . 137
- VEGETATION . . . 141
  - Other Impacts . . . 143
  - Wetlands . . . 143
- LAND USE . . . 146
- FISHERIES AND AQUATIC HABITAT . . . 148
  - Impacts of the Consumptive Use, Instream, and Combination Alternatives . . . 150
- WILDLIFE . . . 157
- HISTORICAL, ARCHAEOLOGICAL, AND PALEONTOLOGICAL RESOURCES . . . 160
  - Impacts of the Consumptive Use, Instream, and Combination Alternatives . . . 161
- RECREATION . . . 164
  - Impacts of the Consumptive Use, Instream, and Combination Alternatives . . . 165
  - Changes in Recreational Value Due to Changes in Streamflows . . . 166

POWER PRODUCTION . . . . . 169
  General Impacts and Considerations . . . . . 169
  Impacts to Hydroelectric Power Production . . . . . 169
  General Impact From Increased Pumping Loads . . . . . 169
SOCIOECONOMICS . . . . . 172
  Employment, Income, Agricultural Sales, and Taxation . . . . . 172
  Impacts of the Consumptive Use, Instream, and Combination Alternatives . . . . . 172
  Population . . . . . 175
  Population Impacts . . . . . 175
  Social Effects . . . . . 175
  Community Services . . . . . 176
NO ACTION ALTERNATIVE . . . . . 176
OTHER REASONABLY FORESEEABLE EVENTS . . . . . 177
  Fort Peck Dam Operation Plans . . . . . 177
  Pallid Sturgeon Recovery Plan . . . . . 179
  Future Development by the Tribes of the Fort Peck Indian Reservation . . . . . 179
  Canadian Development Scenario . . . . . 179
  Canadian Battle Creek Project . . . . . 179
MITIGATION MEASURES THAT COULD BE ADOPTED TO REDUCE ADVERSE EFFECTS . . . . . 181
  Change of Operation at Fort Peck . . . . . 181
  Additional Measures . . . . . 181
IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES . . . . . 181
  Water Availability . . . . . 181
  Water Quality . . . . . 181
  Soils . . . . . 186
  Land . . . . . 186
  Fisheries and Aquatic Habitat . . . . . 186
  Wildlife . . . . . 186
  Vegetation . . . . . 186
  Historical, Archaeological, and Paleontological Resources . . . . . 186
  Recreation . . . . . 186
  Energy and Materials . . . . . 187
  Socioeconomic Resources . . . . . 187
IRRETRIEVABLE LOSSES OF NATURAL RESOURCES AND DEVELOPMENT OPPORTUNITIES RESULTING FROM FAILURE TO RESERVE WATER . . . . . 187

CHAPTER SEVEN: BOARD DECISION CRITERIA . . . . . 189
QUALIFICATIONS AND PURPOSE . . . . . 189
NEED . . . . . 189
AMOUNT . . . . . 189
PUBLIC INTEREST . . . . . 189
DILIGENCE . . . . . 189
NO ADVERSE EFFECT ON SENIOR WATER RIGHTS . . . . . 189
CRITERIA FOR THE BOARD'S DECISION . . . . . 190
QUALIFICATIONS AND PURPOSE . . . . . 190
  Conservation Districts . . . . . 190
  Montana Department of Fish, Wildlife and Parks . . . . . 190
  Municipalities . . . . . 190
  Water Districts . . . . . 190

NEED . . . . . 190
    Conservation Districts . . . . . 190
    Montana Department of Fish, Wildlife and Parks . . . . . 190
    Municipalities and Water Districts . . . . . 190
AMOUNT . . . . . 191
    Conservation Districts . . . . . 191
    Montana Department of Fish, Wildlife and Parks . . . . . 191
    Municipalities and Water Districts . . . . . 192
PUBLIC INTEREST . . . . . 192
    Benefits And Costs Under The Alternatives . . . . . 192
    Benefits . . . . . 193
    Costs . . . . . 193
    Comparison of Benefits and Costs for DNRC's Alternatives . . . . . 195
    Benefits and Costs of Granting Reservations for Individual Projects . . . . . 196
REASONABLE ALTERNATIVES WITH GREATER NET BENEFITS . . . . . 196

# LIST OF APPENDICES

APPENDIX A: SUMMARY OF WATER RIGHT CLAIMS, PERMITS, AND PERMIT APPLICATIONS IN THE MISSOURI RIVER BASIN BELOW FORT PECK DAM . . . . A-1

APPENDIX B: SUMMARY OF WATER RESERVATIONS GRANTED BY THE BOARD IN THE MISSOURI RIVER BASIN ABOVE FORT PECK DAM . . . . . . . . . . B-1

APPENDIX C: METHODS USED BY DFWP TO DETERMINE AMOUNTS REQUESTED FOR INSTREAM FLOWS . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . C-1

APPENDIX D: WATER AVAILABILITY MODELS AND RESULTS . . . . . . . . . . D-1

APPENDIX E: WATER QUALITY INFORMATION FOR LOWER MISSOURI RIVER BASIN STREAMS . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . E-1

APPENDIX F: LOWER MISSOURI VALLEY VEGETATION UNDER EXISTING CONDITIONS AND THE CONSUMPTIVE USE ALTERNATIVE AND PROJECTS AFFECTING WETLANDS IN THE SHERIDAN COUNTY . . . . . . . . . . . . . . . . . . . . . . F-1

APPENDIX G: EXISTING LAND USE WHERE IRRIGATION PROJECTS ARE PROPOSED . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . G-1

APPENDIX H: FISHERIES VALUE CLASS AND RELATIVE FISH ABUNDANCE IN STREAMS WHERE DFWP HAS REQUESTED RESERVATIONS IN THE LOWER MISSOURI RIVER BASIN . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . H-1

APPENDIX I: DFWP'S PROPOSED WATER RESERVATION MANAGEMENT PLAN AND ADMINISTRATIVE PROCEDURES PROPOSED BY THE SHERIDAN COUNTY CONSERVATION DISTRICT. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . I-1
- DFWP MANAGEMENT PLAN . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . I-3
- SHERIDAN COUNTY CONSERVATION DISTRICT. . . . . . . . . . . . . . . . . . . . . . . . . . . . . I-7

APPENDIX J: MONTHLY FLOWS REMAINING AFTER REQUESTED INSTREAM FLOWS ARE SUBTRACTED. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . J-1

APPENDIX K: POPULATION AND WATER USE INFORMATION FOR LOWER MISSOURI RIVER BASIN MUNICIPALITIES . . . . . . . . . . . . . . . . . . . . . . . . . . . K-1

APPENDIX L: ECONOMIC AND FINANCIAL ANALYSIS LOWER MISSOURI RIVER BASIN . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . L-1

# LIST OF TABLES

Table 1-1. Agencies with regulatory jurisdiction relating to water reservations . . . . . . . . . . . . . . . . 2

Table 2-1. Montana water classifications for specific uses . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6
2-2. Water quality criteria for protection of beneficial uses. . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7

Table 3-1. Conservation District Reservation Requests . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11
3-2. Montana Department of Fish, Wildlife and Parks Instream Flow Requests . . . . . . . . . . . 21
3-3. Reservation requested by municipalities . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 24

Table 4-1. Average annual flow in the Milk River subbasin . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 29
4-2. Principal bedrock aquifers in each subbasin . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 33
4-3. Monthly instream flows reserved by compact for streams on the Fort Peck Indian Reservation . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 42
4-4. Lower Missouri basin storage reservoirs with a capacity of more than 5,000 acre-feet . . 43
4-5. Estimated acres of saline seeps by county . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 54
4-6. Existing lower Missouri River valley bottomland plant communities . . . . . . . . . . . . . . . 58
4-7. Vegetation of the Missouri River floodplain below Fort Peck Dam by era . . . . . . . . . . . . 59
4-8. Sensitive plants that occur in areas where irrigation projects are proposed . . . . . . . . . . 60
4-9. Montana noxious weeds . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 60
4-10. Lower Missouri River basin land ownership . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 62
4-11. Fish species of special concern in the Missouri River Basin below Fort Peck Dam . . . . . 66
4-12. Tributaries providing spawning habitat for game fish inhabiting the Milk River . . . . . . . 69
4-13. Species of special concern known to occur in Missouri River subbasins . . . . . . . . . . . . 73
4-14. Sensitive species that might be found in vegetation communities likely to be affected by irrigation development projects . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 74
4-15. List of historical and archaeological sites potentially affected by the proposed conservation district water reservation projects . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 78
4-16. Paleontological significance of major geologic formations in the study area . . . . . . . . . . 79
4-17. Participation by adult Montanans in 11 outdoor recreational activities - 1979 and 1985 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 80
4-18. Lower Missouri River subbasin angler use . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 81
4-19. Milk River subbasin angler use . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 82
4-20. Little Missouri River subbasin angler use . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 82
4-21. Sheridan County Groundwater Area angler use . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 83
4-22. Economic baseline data - lower Missouri River basin . . . . . . . . . . . . . . . . . . . . . . . . . . . 87
4-23. Economic baseline data - lower Missouri River subbasin . . . . . . . . . . . . . . . . . . . . . . . . . 88
4-24. Economic baseline data - Milk River subbasin . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 88
4-25. Economic baseline data - Little Missouri River subbasin . . . . . . . . . . . . . . . . . . . . . . . . . 89
4-26. Economic baseline data - Sheridan County Groundwater Area . . . . . . . . . . . . . . . . . . . . 90

Table 5-1. Reservation requests included under each alternative . . . . . . . . . . . . . . . . . . . . . . . . . . 92
5-2. Proposed projects that would be reduced under the Instream or Combination alternatives . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 98

Table 6-1. Summary of groundwater availability data, Sheridan County Groundwater Area . . . . . 118
6-2. Expected drawdowns at various distances from a pumping well . . . . . . . . . . . . . . . . . . 119
6-3. Summary of applications for groundwater outside of the Sheridan County Groundwater Area . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 122
6-4. Streams where reservations are applied for and where water rights holders objected to permit applications between July 1973 and June 1993 . . . . 124
6-5. Proposed storage projects included in the Consumptive Use Alternative . . . . . . . . . . . 126

6-6. Soil disturbances that would occur due to pipeline and canal construction for each alternativea . . . 133
6-7. Soil concerns for proposed irrigation projects in the lower Missouri River subbasin . . . 135
6-8. Soil concerns for proposed irrigation projects in the Little Missouri River subbasin . . . 136
6-9. Proposed projects on the lower Missouri River where irrigated land would be immediately adjacent to eroding river banks . . . 138
6-10. Proposed projects along the lower Missouri River where pump sites would be located on eroding streambanks . . . 139
6-11. Acres of upland prairie that might be plowed due to reservations in the lower Missouri, Milk, and Little Missouri River subbasins . . . 142
6-12. Acres of moist prairie that might be plowed due to reservations in the lower Missouri, Milk, and Little Missouri River subbasins . . . 142
6-13. Acres of woody draw and bottomland vegetation that might be cleared due to reservations in the lower Missouri, Milk, and Little Missouri River subbasins . . . 142
6-14. Changes in acreage of major vegetation types in the Missouri River bottomlands below Fort Peck Dam for each alternative . . . 142
6-15. Vegetation changes that would occur with the development of proposed irrigation projects in the Missouri River bottomlands below Fort Peck for each alternative . . . 142
6-16. Summary of wetlands inventoried by USFWS within proposed irrigation projects near the Missouri River below Brockton . . . 145
6-17. Lengths of electric lines required for lower Missouri River basin projects that would need 5 miles or more of lines . . . 146
6-18. Likelihood of proposed storage projects supporting a fishery under the Consumptive, Instream, and Combination alternatives . . . 150
6-19. Changes in flow affecting aquatic habitat in the Missouri River near the Montana-North Dakota border under the Consumptive Use, Instream, and Combination alternatives . . . 151
6-20. Changes in flow affecting aquatic habitat in portions of the Poplar River Drainage. . . . 153
6-21. Streams in the Little Missouri River drainage where adverse effects to aquatic habitat might result from the Consumptive Use, Instream, and Combination alternatives. . . . 154
6-22. Streams in the Boxelder Creek drainage where adverse effects to aquatic habitat might result from the Consumptive Use, Instream, and Combination alternatives. . . . 155
6-23. Streams in the Little Beaver Creek drainage where adverse effects to aquatic habitat might result from the Consumptive Use, Instream, and Combination alternatives. . . . 155
6-24. Streams in the Beaver Creek drainage where adverse effects to aquatic habitat might result from the Consumptive Use, Instream, and Combination alternatives. . . . 156
6-25. Projects within 1 mile of known sightings of least terns or piping plovers . . . 158
6-26. Projects in the Little Missouri River subbasin that contain woody draw vegetation adjacent to streams . . . 159
6-27. Projects that would cause Lamesteer Reservoir to fill less frequently . . . 160
6-28. Historical and archaeological sites along the lower Missouri River . . . 162
6-29. Historical and archaeological sites potentially affected by reservations in the Sheridan County Groundwater Area . . . 163
6-30. Changes in average flow due to reservations granted in the upper Missouri River basin and proposed reservations in the lower Missouri River basin . . . 167
6-31. Changes in average flow (acre-feet) due to lower Missouri River basin proposed reservations . . . 167
6-32. Changes in annual value of recreation due to reservations granted in the upper Missouri River basin and proposed reservations in the lower Missouri River basin . . . 168
6-33. Changes in annual value of recreation due to proposed reservations in the lower Missouri River basin . . . 168
6-34. Cumulative reductions in hydroelectric production, increased power demands, and costs to ratepayers due to reservations granted in the upper Missouri basin

and requested reservations in the lower Missouri River basin . . . . . . . . . . . . . . . . . . . 170
6-35. Reductions in hydroelectric production, increased power demands, and costs to ratepayers due to water reservations requested in the lower Missouri basin . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 171
6-36. Economic benefits to agriculture under various alternatives - lower Missouri River basin . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 172
6-37. Economic benefits to agriculture under various alternatives - lower Missouri River subbasin . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 173
6-38. Economic benefits to agriculture under various alternatives - Milk River subbasin. . . . 173
6-39. Economic benefits to agriculture under various alternatives - Little Missouri River subbasin . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 174
6-40. Economic benefits to agriculture under various alternatives - Sheridan County Groundwater Area . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 174
6-41. Summary of population projections for the lower Missouri River basin municipalities . 175
6-42. Changes in flow affecting aquatic habitat in the Missouri River near the Montana-North Dakota border under the No Action and Canadian development scenario. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 178
6-43. Measures that could be adopted to reduce impacts . . . . . . . . . . . . . . . . . . . . . . . . . 184

Table 7-1. Benefits and costs under the alternatives . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 194
7-2. Benefits and costs of reservations for irrigation and municipal uses . . . . . . . . . . . . . . 195

## LIST OF MAPS

Map 3-1. Lower Missouri River Basin and subbasins . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 10
3-2. Proposed conservation district projects in the Lower Missouri River Subbasin . . . . . . . . 17
3-3. Proposed conservation district projects in the Milk River Subbasin . . . . . . . . . . . . . . . 18
3-4. Proposed conservation district projects in the Little Missouri river Subbasin . . . . . . . . . 18
3-5. Groundwater development projects proposed by the Sheridan County Conservation District . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19
3-6. Location of instream flow requests in the Lower Missouri River subbasin . . . . . . . . . . . 22
3-7. Location of instream flow requests in the Milk River subbasin . . . . . . . . . . . . . . . . . . 23
3-8. Location of instream flow requests in the Little Missouri River subbasin . . . . . . . . . . . . 23
3-9. Municipalities and water districts that have applied to reserve water in the basin . . . . . 25

Map 4-1. Principal aquifers in the Sheridan County Groundwater Area . . . . . . . . . . . . . . . . . . . . 35
4-2. Status of Water Rights Adjudication in the Lower Missour Basin . . . . . . . . . . . . . . . . . 38
4-3. Locations of Montana Indian reservations . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 40
4-4. Designated lands in the Lower Missouri River basin . . . . . . . . . . . . . . . . . . . . . . . . . 63
4-5. Irrigated land in the Lower Missouri River Basin . . . . . . . . . . . . . . . . . . . . . . . . . . . 65
4-6. Wildlife lands in the Sheridan County Groundwater Area . . . . . . . . . . . . . . . . . . . . . 75
4-7. Distribution of fishing use among Montana river subbasins . . . . . . . . . . . . . . . . . . . . 80

## LIST OF PHOTOS

Photo 6-1. Severe erosion in the vicinity of projects CT-153 and CT-154 . . . . . . . . . . . . . . . . . . 137
6-2. A portable irrigation pump on the lower Missouri River . . . . . . . . . . . . . . . . . . . . . . . 138
6-3. A permanent pumping station for a large irrigation project on the lower Missouri River 139

# LIST OF FIGURES

Figure 4-1. Consumptive Water Use by subbasin . . . . . 28
4-2. Average monthly flows for the Missouri River below Fort Peck Dam . . . . . 30
4-3. Typical August daily Missouri River flow fluctuation that results from peaking operations at Fort Peck Dam . . . . . 30
4-4. Hourly releases from Fort Peck Reservoir for July 14-20, 1985 illustrating large variations in hourly flows . . . . . 31
4-5. Daily fluctuation in Missouri River stage with a typical June release pattern . . . . . 31
4-6. Average monthly flows for the Milk River . . . . . 32
4-7. Average monthly flows for the Little Missouri River at Camp Crook, South Dakota . . . . . 33
4-8. Water levels in selected wells in unconsolidated aquafers, 1982-1993 . . . . . 37
4-9. Relationship between arsenic concentrations and streamflows in the Missouri River . . . 47
4-10. Comparison of suspended sediment loads for the Missouri River near Landusky, Culbertson and below Fort Peck Dam . . . . . 50
4-11. Suspended sediment data for the East Poplar River at International boundary for period 1981-90 . . . . . 50
4-12. Population trends in Lower Missouri River Basin counties . . . . . 61
4-13. Pallid Sturgeon (*Scaphirhynchus albus*) . . . . . 67
4-14. Paddlefish (*Polyodon spathula*) . . . . . 67
4-15. Present and pre-dam flows below Fort Peck Dam . . . . . 68
4-16. Least Tern in flight . . . . . 71
4-17. Piping Plover with young . . . . . 71
4-18. Montana employement trends . . . . . 83
4-19. Lower Missouri River basin employement trends . . . . . 84
4-20. Montana earnings trends . . . . . 85
4-21. Lower Missouri River basin earnings trends . . . . . 85

Figure 6-1. Computed streamflows in the Missouri River below Fort Peck Reservoir under each alternative . . . . . 103
6-2. Computed streamflows in the Missouri River near Wolf Point under each alternative . . 104
6-3. Computed streamflows in the Missouri River at the North Dakota state-line under each alternative . . . . . 105
6-4. Computed streamflows in Poplar River at mouth under each alternative . . . . . 106
6-5. Computed streamflows for the Milk River near Harlem under the Consumptive Use Alternative both with and without the proposed Virgelle diversion . . 108
6-6. Computed streamflows in Milk River at Dodson under each alternative . . . . . 109
6-7. Computed streamflows in the Milk River near Nashua under each alternative . . . . . 110
6-8. Computed streamflows in Battle Creek at its mouth under the Consumptive Use Alternative . . . . . 111
6-9. Computed streamflows in the Little Missouri River under each alternative . . . . . 113
6-10. Computed streamflows in the Boxelder Creek under each alternative . . . . . 114
6-11. Computed streamflows in Little Beaver Creek under each alternative . . . . . 115
6-12. Computed streamflows in Beaver Creek under each alternative . . . . . 116
6-13. Cone of depression formed when a well is pumped, showing drawdown at observation wells . . . . . 118
6-14. Irrigated alfalfa yield trends and projection in Missouri River basin counties . . . . . 147
6-15. Monthly streamflows for the Milk River at Nashua under the Canadian Development Scenario . . . . . 180
6-16. Computed streamflows in the Missouri River at the Montana-North Dakota border if Fort Peck Reservoir is operated to shift flow reductions under the Consumptive Use Alternative to the months December, January, and February . . . . . 182
6-17. Fort Peck Reservoir elevations under the Fort Peck Mitigation Scenario . . . . . 183

# GLOSSARY

**Aquifer:** A porous subsurface formation that contains groundwater.

**Baseline:** Pertaining to existing conditions.

**Consumptive Water Use:** Any use of water that results in water being consumed by plants, evaporated, or otherwise lost from its source and unavailable for other use.

**Contested case hearing:** A public hearing held if valid objections from existing water right holders are received to water reservation applications. The findings of the hearing will be submitted to the Board which will use them when reaching a decision on the water reservation applications.

**Dead storage:** In a reservoir, water which cannot be withdrawn because it is below the level of the outlet.

**Discharge:** The total volume of water in a stream passing a given point over a given period of time—quantified in this EIS as cubic feet per second, or "cfs."

**Gigawatt:** One billion watts, 1,000 megawatts.

**Irrigation return flow:** Water that returns to a surface water body after irrigation.

**Mitigation:** In the case of environmental impacts, an effort to avoid, minimize, or reduce such impacts.

**Nanogram:** One billionth of a gram (.000000001 grams).

**Net present value:** The value today of a sum of money that will be paid or earned in the future.

**Percentile exceedance flows:** Flow rates which have been equalled or exceeded at a given frequency over a given period of record.

**Riparian:** Relating to or living on the bank of a stream or other water body.

**Water diversion:** The removal of water from its source by use of a canal, ditch, pipe, or other conveyance.

**Water rights, permits, reservations, etc.:** See Chapter Two for definitions of all terms relating to water law.

## CHAPTER ONE

# INTRODUCTION

In 1985, the Montana Legislature directed the Department of Natural Resources and Conservation (DNRC) to initiate and coordinate a proceeding that allows public entities (state and federal agencies and subdivisions of the state) to reserve water in the Missouri River basin of Montana for future use. This reservation proceeding was initiated for two reasons. First, it was thought that the comprehensive planning required in a reservation process would encourage more efficient development of the water resources in the basin. Second, the reservation proceeding was seen as a way to build a strong legal basis for protecting Montana's share of Missouri River water in any future litigation with other states or in a congressional apportionment of the water between states.

The legislature was particularly concerned that downstream states might litigate for the guaranteed delivery of Missouri River flows from Montana. Montana can best prepare for negotiation or litigation by identifying its present and future water needs and legally reserving water in amounts sufficient to meet those needs.

In reservation proceedings, local governments, conservation districts, and state and federal agencies are encouraged to apply to reserve water for existing and future water-consuming uses or to maintain a minimum flow, level, or quality of water (§85-2-316, MCA). Under the law, DNRC is responsible for assisting in preparing the reservation applications and for coordinating the reservation process. The Board of Natural Resources and Conservation (Board), a governor-appointed group of seven citizens, decides whether to grant, deny, or modify reservation requests. The Board's decisions on reservation applications in the Missouri River basin will be based on a record of evidence that includes the information provided in the applications, environmental impact statement, and a contested case hearing.

Due to the vast size of this basin, the Missouri River reservation proceeding has been split into two parts. Applications for water in the upper portion of the basin, which encompasses the drainage area upstream from Fort Peck Dam, were considered first. After an environmental review and contested case hearing, the Board made a final decision on the upper basin applications in June 1992.

This draft environmental impact statement (EIS) addresses applications for the reservation of water in the Missouri River basin in Montana below Fort Peck Dam. The legislature required applications for water in the basin below Fort Peck Dam, including the Little Missouri River and Milk River basins, to be submitted to DNRC by July 1, 1991, and these will undergo similar review and hearings. The Board has until December 31, 1994, to act on these applications. Any reservation granted in the Missouri and Milk River basins will receive a priority date of July 1, 1985. The priority date for any reservations granted in the Little Missouri River basin will be July 1, 1989.

## EIS PROCESS

This draft EIS was prepared to satisfy the Montana Water Use Act and the Montana Environmental Policy Act (MEPA). MEPA requires that an EIS be prepared to address government actions that might significantly affect the quality of the environment. DNRC determined that the reservation applications would require an EIS. This EIS provides information for the Board to use in deciding whether it should grant, modify, or deny water reservations that have been applied for in the lower Missouri River basin. It also serves to inform the public of the possible consequences of any action by the Board on the pending water reservation applications.

All pending water reservations requested in the Milk River basin, Little Missouri River basin, and Missouri River basin below Fort Peck Dam are included in this EIS, which also describes in general terms the reservation requests and the parties and resources that would be affected if the requests are granted. Effects in the lower Missouri River basin due to reservations granted above Fort Peck Dam also will be taken into account. Significant, basinwide issues and the cumulative effects of granting the reservations are the main focus of the EIS.

The public has several opportunities to participate in the EIS process. In the first of these, public meetings were held to help determine the issues that should be examined in the EIS. These issues, along with information from state and federal agencies, were combined with research results and other data to form the draft EIS. The draft EIS is distributed to the public to give interested parties the opportunity to review it and comment. DNRC will hold public meetings to gather written and oral comments on the draft EIS. DNRC will then publish a final EIS responding to comments and providing information on issues raised following publication of the draft EIS.

## CONTESTED CASE HEARING

Early in 1994, DNRC will issue legal notice of the reservation applications to water right holders and other interested parties. Written objections can then be submitted to DNRC. The Board appoints a hearings examiner and holds a formal contested case hearing if valid objections are received. Applicants and objectors can present testimony and evidence at the hearing. The hearing is the final opportunity for public involvement. After the hearing, the hearings examiner presents findings and recommendations to the Board. Based on its review of this record, the Board adopts findings and issues a decision that can fully grant, partially grant, modify, or deny requested reservations.

## WHO HAS APPLIED

DNRC received applications from 11 conservation districts to provide water for 471 irrigation and reservoir projects; from 14 municipalities; and from the Montana Department of Fish, Wildlife and Parks (DFWP) for instream flows on 21 stream segments. A more detailed list and discussion of the applicants' requests are presented in Chapter Three.

## AGENCIES WITH ADDITIONAL PERMITTING AUTHORITY

If the Board grants reservations, other agencies may have additional regulatory jurisdiction over project development. These agencies are listed in Table 1-1.

**Table 1-1. Agencies with regulatory jurisdiction relating to water reservations**

| Agencies | Regulated activities |
|---|---|
| Conservation districts | Regulate private projects that affect the bed or banks of perennial streams |
| Counties | Regulate facilities within designated floodplains |
| Department of Fish, Wildlife and Parks | Regulates governmental projects that affect streams and consults with conservation districts regarding private projects |
| Department of Health and Environmental Sciences | Administers permitting process for water quality, air quality, and solid and hazardous wastes |
| Department of Natural Resources and Conservation | Issues water use permits and change of use permits; regulates dam safety |
| Department of State Lands | Regulates easements across state lands |
| State Historic Preservation Office | Administers Historic Preservation Act for projects affecting archaeological and historical resources |
| U.S. Army Corps of Engineers | Administers 404 water quality and wetland disturbance permits; regulates easements across public lands |
| U.S. Bureau of Land Management | Regulates special use permits and easements across public land |
| U.S. Fish and Wildlife Service | Administers Endangered Species Act |

## CHAPTER TWO

# MONTANA WATER LAW

## INTRODUCTION

Water use in Montana is generally guided by the prior appropriation doctrine. One of the legal principles under the prior appropriation doctrine is "first in time is first in right." The first person to use water from a source establishes the first right, the second person is free to divert flows from what is left, and so on. During a dry year, the person with the earliest priority date has first chance at the available water to the limit of his or her established right. The holder of the second earliest priority date has the next chance, and so on.

Another central element of the prior appropriation doctrine is that the water must be put to beneficial use. The Montana Supreme Court has stated that beneficial use is the "basis, measure, and limit" of a water right. McDonald v. State, 220 Mont. 519 (1986). Under Montana law, beneficial uses include, but are not limited to, agriculture (including stock water), domestic, fish and wildlife, industrial, irrigation, mining, municipal, power, and recreational uses. The nature and extent of a water right is defined by how water has been beneficially used in the past. Once a water right is established, it can be lost through abandonment if the beneficial use is not continued.

Under the prior appropriation doctrine in Montana, there are various "types" of water rights depending on what procedure for obtaining a water right was in force at the time the right was established. However, the basic principles of first in time, first in right, and beneficial use apply to all types of water rights acquired under state law.

The most significant change in how water rights are created and administered occurred in 1973 when the legislature enacted the Montana Water Use Act. The Water Use Act, effective July 1, 1973, recognized and confirmed water rights that had been used in the past. But, because there were only incomplete records to determine what water had been used, the act also created a system for filing claims and adjudicating those historical rights. This adjudication process also includes water rights claimed under federal law by Indian tribes and the federal government. Further, the act established a new administrative permit system for obtaining a water right after July 1, 1973.

## STATE WATER RIGHTS

### EXISTING RIGHTS

Water rights created prior to 1973 are commonly referred to as existing rights. One way existing rights were obtained was by filing for the water with the county clerk and recorder and then putting the water to beneficial use. Such a right is called a filed right. A filed right has a priority date as of the date of filing, if the appropriator diligently put the water to beneficial use. Existing rights also were obtained by diverting, impounding, or withdrawing water and putting it to beneficial use (use right). The priority date for a use right was the date the water was actually put to beneficial use. Some existing water rights (decreed rights) were adjudicated and recorded by local district courts as a result of water disputes.

A 1979 law required all holders of water rights created prior to July 1, 1973, to file a claim for those rights by April 30, 1982, or the rights would be deemed abandoned. However, the 1993 Legislature passed Senate Bill 310, which allows late claims to be filed until July 1, 1996. The Water Court is conducting a general statewide adjudication to determine the validity of all claimed pre-1973 rights. (When a judge hears a case and renders a decision, the matter is said to have been adjudicated. In the matter of water rights, adjudication refers specifically to the settling of claims filed for water rights.) Refer to Chapter Four for a discussion of the status of adjudication.

### PERMITS

Since the enactment of the Water Use Act of 1973, persons seeking to obtain a water right must apply for a permit from DNRC. The priority date for a water use permit is the date that DNRC accepts the application. For a summary of existing water right claims and permits by type of use in the lower Missouri River basin, see Appendix A.

## WATER RESERVATIONS

Montana has created a unique class of water rights labeled water reservations. Under the water reservation system, water is appropriated for existing instream or future water-consuming uses. Essentially, water reservations are similar to water right permits. However, there are important distinctions in who can hold this type of water right, the requirements for establishing the rights, the process for obtaining them, and in some cases, the possibility of having the rights reallocated to another use. Under the water reservation statute, only state or federal agencies or political subdivisions of the state may apply for a water reservation (§85-2-316(1), MCA). Water reservations may be acquired for any beneficial use.

The water reservation statute is the only means to acquire a water right for instream flows to protect water quality, fish, wildlife, and recreation. The purpose of instream flows is to maintain a minimum flow, level, or quality of water in a stream throughout the year, or for a length of time designated by the Board. These flows can be reserved without the usual requirement for withdrawal, impoundment, or diversion of the water and can be implemented immediately upon being granted.

The water reservation statute also allows water to be appropriated now for future consumptive use. By appropriating the water before it is needed, the reservant maintains an early priority date even though it may be years or decades into the future before the water is actually developed.

The Board of Natural Resources and Conservation is responsible for issuing orders adopting water reservations. Before an order reserving water may be adopted, the applicant must establish to the Board's satisfaction:

1. The purpose of the reservation
2. The need for the reservation
3. The amount of water necessary for the purpose of the reservation
4. That the reservation is in the public interest.

The Board's decision-making process regarding water reservations is covered by the Administrative Procedure Act (APA). Under the APA, appeal for judicial review by the district court is provided for any party who fully participates in the contested case hearing (typically not persons offering public testimony only) and who is aggrieved by the Board's final decision (§2-4-704(1), MCA).

However, the district court is limited in what it can review. The court will review only the record established by the Board and will not consider new evidence or testimony unless the appellant can show good reason why it wasn't presented to the Board. The court cannot substitute its judgement for the Board's, but can modify or reverse the Board's decision in the following situations:

1. The administrative findings, inferences, conclusions, or decisions are:
   - (a) In violation of constitutional or statutory provisions;
   - (b) In excess of the statutory authority of the agency;
   - (c) Made upon unlawful procedure;
   - (d) Affected by other error of law;
   - (e) Clearly erroneous in view of the reliable, probative, and substantial evidence on the whole record;
   - (f) Arbitrary or capricious or characterized by abuse of discretion or clearly unwarranted exercise of discretion; or
2. Findings of fact upon issues essential to the decision were not made, though they were requested (§2-4-704(2)(a,b), MCA).

The district court's decision can be appealed to the Montana Supreme Court.

A water reservation, when adopted by the Board, becomes a water right. However, if the objectives of the reservation are not being met, the Board can later modify or revoke that water right. The Board must review water reservations at least once every 10 years to ensure that the objectives of the reservation are being met. In the case of instream flows granted by the Board, all or a portion of the flow may be reallocated to a different use if the applicant for reallocation is a qualified reservant and can show that the instream flow is not required for its purpose and that the need for reallocation to the applicant outweighs the need shown by the original reservant. (§85-2-316(11), MCA.)

Water reservations have been established in the Yellowstone River basin. In 1978, the Board granted water reservation applications for agriculture (stock water), irrigation, municipal, fish and wildlife, water quality, and storage.

Two water reservation applications in the basin of the upper Clark Fork of the Columbia, one for instream flows and one for two storage projects for agricultural purposes, are currently pending.

In June 1992, the Board acted on water reservation applications in the upper Missouri River basin above Fort Peck Dam. Reservations were granted for irrigation; municipal use; fish, wildlife and recreation, and water quality. Appendix B contains a summary of reservations granted by the Board in the upper basin. In its final order, the Board placed stipulations on instream flow and irrigation reservations that limit the force and effect of these reservations in basins closed to the issuance of new water use permits. Then the 1993 Legislature passed bills closing the Madison, Jefferson, and Teton basins, and the Missouri River basin above Morony Dam near Great Falls to most new water use permits. These closures substantially limit the force and effect of the instream flow and irrigation reservations granted by the Board in those basins. The Board's order has been appealed. The appeals are pending before the district court.

Any water reservations granted in lower Missouri River and Milk River basins under the present reservation process will have a priority date of July 1, 1985. (§85-2-316, MCA.) In 1989, the legislature added the Little Missouri River basin to the Missouri River basin reservation process. The priority date for any water reservations granted in the Little Missouri River subbasin will be July 1, 1989. Although any reservations granted have the designated priority dates, the Board must further establish priorities among reservations granted with that priority date. One reservation may be established at 8 a.m., and the next at 8:05, and so on.

Persons who receive a water use permit on the Missouri River with a priority date between July 1, 1985, (or July 1, 1989, in the case of the Little Missouri River) and the date the Board adopts an order granting a water reservation may seek to have any or all reservations subordinated to the permit. However, for the Board to subordinate a reservation to a permit, the permit holder must show that the subordination will not interfere substantially with the purpose of the reservation.

### FEDERAL RESERVED RIGHTS

A federal reserved water right is implied by an act of Congress, a treaty, or an executive order establishing a tribal or federal reservation. The amount of water reserved under such a right depends on the purpose for which the land was reserved. In Montana, reserved water rights have been claimed for seven Indian reservations inside the state and Indian allotments for members of the Turtle Mountain Chippewa, whose reservation is in North Dakota. Reserved water also has been claimed for federal land holdings in Montana, including the national parks, forests, wildlife refuges, and a federally designated wild and scenic river (see Chapter Four).

The Montana Reserved Water Rights Compact Commission, created in 1979, is authorized to negotiate settlements with federal agencies and Indian tribes that claim federal reserved water rights within the state. These settlements will eventually be adjudicated, but are suspended from adjudication while they are being negotiated by the compact commission.

## WATER LEASING FOR INSTREAM FLOWS

The 1989 and 1993 legislatures authorized DFWP to lease existing water rights for instream flows (§85-2-436, MCA) as part of a study program. The purpose of the legislation is to examine the feasibility of leasing existing water rights to maintain and enhance streamflow for fisheries. This 10-year pilot program allows DFWP to lease water from willing water right holders for no more than 20 stream reaches. To date, DFWP has entered into two leases, both for flows in Mill Creek in the Yellowstone River basin.

## WATER QUALITY REGULATIONS

The Montana Department of Health and Environmental Sciences (DHES), in conjunction with the Board of Health and Environmental Sciences (BHES), administers programs and laws to protect, maintain, and improve the quality of water for all beneficial uses. Under the authority of the Montana Water Quality Act and the Federal Clean Water Act, DHES enforces water quality standards for surface water and groundwater, issues permits for wastewater discharges, reviews the operation and maintenance of municipal and industrial wastewater treatment facilities, and monitors wastewater discharges and ambient water quality. DHES also is responsible for toxic substance control and oversight of activities affecting water quality to ensure compliance with the

Federal Clean Water Act and the Montana Water Quality Act.

The Montana Water Quality Act establishes surface water quality standards and a water use classification system to protect, maintain, and improve the quality of water. Montana's classification scheme is summarized in Table 2-1.

Montana's water quality classifications are based on beneficial uses and reflect the state's varied water quality problems and natural conditions. Specific physical, chemical, and biological criteria are used to establish the quality of water necessary to support a given beneficial use (Table 2-2).

To protect beneficial uses, DHES has adopted water quality standards that establish maximum allowable changes in surface water quality for each stream on the basis of its classification. Standards vary for each classification (Table 2-1).

DHES administers a variety of programs to protect groundwater quality, including the Montana Ground Water Pollution Control System, which was approved by BHES in October 1982. The program includes groundwater quality standards, a classification system, a permitting program for potential pollution sources, and a nondegradation policy. The program has focused on mine discharges, ruptured pipelines, and spills of hazardous materials. In 1989, the Montana Agriculture Chemical Ground Water Protection Act was enacted by the legislature. The act authorizes education, groundwater monitoring, setting of groundwater standards for agricultural chemicals, and development of groundwater management plans. These programs are relatively new and in the initial stages of implementation. Groundwater supplies used for drinking water must meet the criteria for public water supplies (Table 2-2).

Along with the surface water quality standards, BHES has established Montana nondegradation rules that prohibit increases in concentration of substances in surface water and groundwater for which limits are set by the federal Safe Drinking Water Act. These rules also apply to substances listed in EPA's "Gold Book" (EPA 1986).

**Table 2-1. Montana water classifications for specific uses**

A-CLOSED: Suitable for drinking, culinary, and food processing purposes after simple disinfection.

A-1: Suitable for drinking, culinary, and food processing purposes after conventional treatment for removal of naturally present impurities.

B-1: Suitable for drinking, culinary, and food processing purposes after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.

B-2: Suitable for drinking, culinary, and food processing purposes after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.

B-3: Suitable for drinking, culinary, and food processing purposes after conventional treatment; bathing, swimming, and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.

C-1: Suitable for bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.

C-2: Suitable for bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.

C-3: Suitable for bathing, swimming, and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl, and furbearers. The quality of these waters is naturally marginal for drinking, culinary, and food processing purposes and agricultural and industrial water supply. Degradation that will affect established beneficial uses will not be allowed.

I: The goal of the State of Montana is to have these waters fully support the following uses: drinking, culinary, and food processing purposes after conventional treatment; bathing, swimming, and recreation; growth and propagation of fisheries and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.

**Table 2-2. Water quality criteria for protection of beneficial uses (maximum values in parts per million unless otherwise noted)[1,12]**

| Parameters | HH(FW)[2] | PWS[3] | A(C)[4] | A(W)[5] | REC[6] | AGR[7] |
|---|---|---|---|---|---|---|
| Dissolved oxygen | narrative[8] | | ≥7.0 | ≥5.0 | | |
| Fecal coliforms[9] | | | | | 200 | 1,000 |
| Nitrite as nitrogen | | 1.0 | 0.06 | 5.0 | | 10.0 |
| Nitrate as nitrogen | 10.0 | 10.0 | | | | 100 |
| Total ammonia | narrative[8] | 0.5 | | | | |
| Un-ionized ammonia | narrative[8] | | 0.03 | 0.03 | | |
| Total inorganic nitrogen | | | 1.00 | 1.00 | | |
| Total phosphorus | | | 0.10 | 0.10 | 0.10 | |
| Total dissolved solids | 250.0 | 500 | | | | 1,200 |
| Conductance (micromhos/cm) | narrative[8] | | | | | 1,800 |
| Turbidity (NTU)[10] | narrative[8] | | 10 | 50 | | |
| Total suspended solids | narrative[8] | | 30 | 90 | | |
| Chloride | | 250 | | | | 700 |
| Sulfate | | 250 | | | | |
| Cyanide | 0.2 | 0.2 | 0.0052 | 0.0052 | | |
| Sodium | | | | | | 160 |
| Sodium adsorption ratio | | | | | | 5.0 |
| Fluoride | | 2.4 | | | | 2.0 |
| Arsenic | 0.000020 | 0.05 | 0.19 | 0.19 | | 0.10 |
| Barium | | | 1.00 | | | |
| Boron | 1.0 | | | | | 0.75 |
| Chromium VI | 0.050 | 0.05 | 0.011 | 0.011 | | 1.00 |
| Chromium III | 170.00 | 0.05 | 0.210 | 0.210 | | |
| Iron | 0.3 | 0.3 | 1.0 | 1.0 | | 20.0 |
| Manganese | 0.050 | 0.05 | | | | 10.0 |
| Selenium | 0.010 | 0.01 | 0.035 | 0.035 | | 0.02 |
| Mercury | 0.000144 | 0.002 | 0.002 | 0.002 | | 0.01 |
| Copper | | 1.0 | 0.012 | 0.012 | | 0.5 |
| Lead | 0.05 | 0.05 | 0.003 | 0.003 | | 0.10 |
| Zinc | | 5.0 | 0.047 | 0.047 | | 10.0 |
| Cadmium | 0.010 | 0.01 | 0.001 | 0.001 | | 0.05 |
| Nickel | 0.0134 | 0.015 | 0.096 | 0.096 | | 2.0 |
| Silver | 0.05 | 0.05 | 0.004 | 0.004 | | |
| pH (minimum)[11] | | 6.5 | 6.5 | 6.5 | 6.5 | 4.5 |
| pH (maximum)[11] | | 8.5 | 8.5 | 9.0 | 8.5 | 9.0 |
| Temperature (C) | narrative[8] | | 19.4 | 26.6 | | |
| Temperature (F) | narrative[8] | | 67.0 | 80.0 | | |

≥ Greater than or equal to

1 Criteria shown are generalized guidelines for protecting various beneficial uses. Criteria listed for some parameters have been adopted as enforceable standards. These standards vary by stream classification—see 16.20.603 ARM (Water Quality, Subchapter 6) for a complete description of water quality standards.

2 Human Health (Fish and Water): U.S. EPA "Gold Book" values for ambient surface water—based on consumption of fish and water.

3 Public Water Supplies: Federal drinking water standard for municipal water.

4 Aquatic Life (Cold Water): Maintenance and propagation of salmonid or cold water fisheries.

5 Aquatic Life (Warm Water): Maintenance and propagation of warm water fisheries.

6 Recreation: Suitability for swimming and waterborne recreation.

7 Agriculture: Suitability for irrigation and livestock consumption.

8 Recommended criteria are given in narrative form—single numeric values are inappropriate (see ARM 16.20.601 through 16.20.630).

9 Measured in geometric mean number of organisms per 100 milliliters.

10 Nephelometric turbidity units—a measure of light penetration through water.

11 Measured in pH units that indicate hydrogen ion concentration.

12 Specific numeric criteria are not listed in Table 2-2 for some parameters because the level at which uses are impaired depends on temperature, pH, and water hardness.

## CHAPTER THREE

# DESCRIPTION OF RESERVATION REQUESTS

In this chapter, the actions proposed by each applicant are summarized. These summaries present the views of the applicants as expressed in their reservation applications. DNRC evaluated this information and presents its analysis in Chapters Five through Seven. Each summary includes:

1. The purpose of the reservation request
2. The need for the reservation
3. The methods used by the applicants to determine the amount(s) of water requested
4. Why the reservation is in the public interest

To help simplify the discussion of the reservation requests and the resources affected by them, the lower Missouri River basin has been divided into four subbasins (Map 3-1). The Milk River subbasin includes the Milk River and its tributaries. The Missouri River from Fort Peck Dam to the North Dakota boundary and all tributaries except the Milk River are included in the lower Missouri River subbasin. The Little Missouri River subbasin includes the Little Missouri River, Boxelder Creek, Little Beaver Creek, Beaver Creek, and all tributaries of these streams. The Sheridan County Groundwater Area also has been designated as a subbasin because all reservation requests in that area would use groundwater from a relatively distinct aquifer system. The Sheridan County Groundwater Area includes a portion of Big Muddy Creek.

## CONSERVATION DISTRICT APPLICATIONS

Eleven conservation districts applied to reserve water, primarily for irrigation. Both partial-service and full-service irrigation has been proposed, and project designs include sprinkler, flood, and water spreading systems. Individual projects would use either surface water or groundwater or both, and water storage is proposed by the Blaine and Liberty county conservation districts. The Little Beaver and Sheridan County conservation districts applied to reserve water for livestock. In their applications, all the conservation districts state similar purposes, needs, general methods of determining amounts needed, and public interest criteria. The reservation requests included in the conservation district applications are summarized in Table 3-1 and shown on Maps 3-2 through 3-5.

### PURPOSE

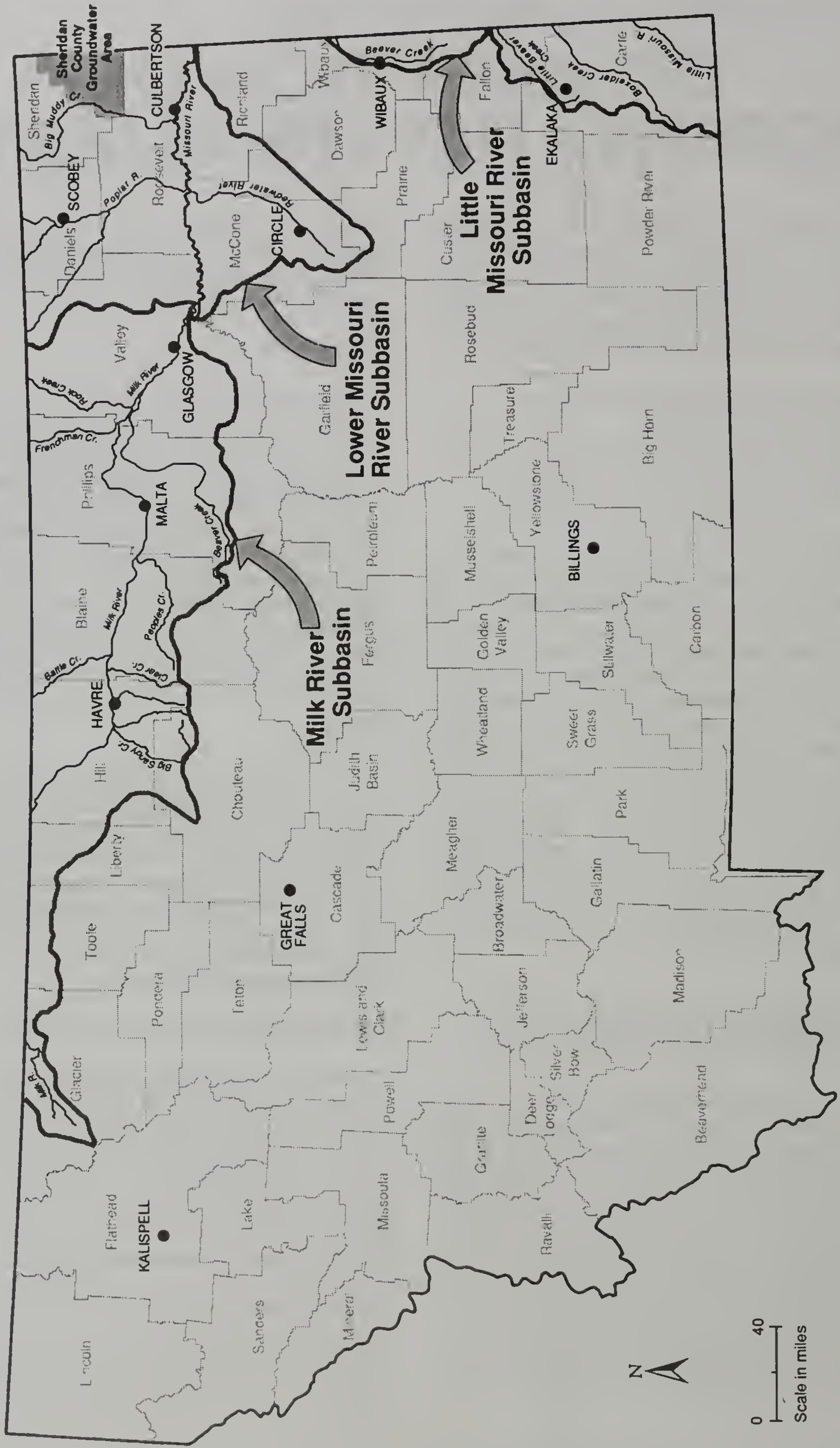
The general purpose of the conservation district applications is either to reserve water for new irrigation projects or to provide supplemental water for existing irrigation. If a conservation district's reservation request is granted in full or part, the landowners or lessees whose projects have been included in the application would be eligible to use that water on a first-come-first-served basis. The districts would administer the distribution of reserved water among district cooperators. The reservations would help ensure that water would be legally available for the irrigation projects identified in the applications.

### NEED

The conservation districts believe they need to reserve water for the proposed irrigation projects because of (1) the threat to future water availability arising from water demands of downstream states and other prospective users, (2) a desire to improve long-range planning efforts, and (3) the prospect that higher prices for farm products in the future will make additional water-dependent agricultural production economically feasible.

### DETERMINATION OF AMOUNT

The conservation districts determined how much water to reserve by identifying potential projects and then determining the amount of water required for them. The districts, along with DNRC and the consultant the districts hired to help with the applications, in many instances relied on the knowledge of private operators to identify potential irrigation projects. Project designs for potentially irrigable land identified in previous studies (DNRC 1987 and SCS undated) also were included with the approval of conservation district supervisors. The physical availability and quality of the proposed water sources were then considered in screening projects to be included in the reservation applications.



Map 3-1. Lower Missouri River Basin and subbasins

Table 3-1. Conservation District Reservation Requests

| Project Number | TWN | Dam Location RGE | SEC | Maximum Storage (af) | Annual Diversion (af) | Water Source | Project Acres |
|---|---|---|---|---|---|---|---|
| **Blaine County Conservation District** | | | | | | | |
| BL-131 | 35N | 26E | 13 | 169 | 164 | Tributary Black Coulee | 70 |
| BL-171 | 35N | 18E | 14 | 172 | 172 | Link Coulee/Battle Creek | 71 |
| BL-181 | 36N | 18E | 16 | 18,593 | 10,600 | Battle Creek | 6,000 |
| TOTALS | | | | 18,934 | 10,936 | | 6,141 |

| Project Number | TWN | Point of Diversion RGE | SEC | Peak Flow (cfs) | Annual Use (af) | Water Source | Project Acres |
|---|---|---|---|---|---|---|---|
| **Carter County Conservation District** | | | | | | | |
| CT-011 | 7S | 60E | 16 | 5.0 | 425 | Little Missouri River | 157 |
| CT-012 | 7S | 60E | 16 | a | 260 | North Butte Creek | 173 |
| CT-041 | 2N | 57E | 33 | a | 195 | Little Beaver Creek | 130 |
| CT-071 | 2N | 57E | 13 | 1.3 | 186 | Little Beaver Creek | 80 |
| CT-121 | 1S | 60E | 4 | 2.8 | 255 | Boxelder Creek | 94 |
| CT-122 | 1S | 60E | 9 | a | 90 | Lampkin Gulch | 60 |
| CT-131 | 6S | 62E | 11 | 2.4 | 240 | Little Missouri River | 88 |
| CT-141 | 8S | 58E | 14 | a | 120 | UT Long Draw | 80 |
| CT-151 | 4S | 58E | 25 | a | 54 | Sherril Creek | 36 |
| CT-152 | 4S | 59E | 30 | a | 17 | UT Boxelder Creek | 11 |
| CT-153 | 5S | 58E | 13 | a | 84 | Hawksnest Creek | 56 |
| CT-154 | 4S | 59E | 27 | a | 14 | UT Boxelder Creek | 9 |
| CT-161 | 7S | 62E | 34 | a | 42 | Elkhorn Creek | 28 |
| CT-162 | 7S | 62E | 34 | a | 50 | UT Elkhorn Creek | 33 |
| CT-171 | 1S | 58E | 22 | a | 165 | Fresh Water Draw | 110 |
| CT-181 | 5S | 62E | 21 | a | 225 | Cottonwood Creek | 150 |
| CT-191 | 7S | 61E | 1 | 3.8 | 247 | Little Missouri River | 91 |
| CT-221 | 1S | 60E | 17 | 2.5 | 311 | Boxelder Creek | 115 |
| CT-241 | 6S | 62E | 15 | 2.6 | 269 | Little Missouri River | 99 |
| CT-243 | 6S | 62E | 36 | a | 9 | UT Beaver Creek | 6 |
| CT-244 | 6S | 62E | 24 | a | 105 | N.F. Beaver Dam Creek | 70 |
| CT-251 | 1N | 61E | 16 | 3.1 | 290 | Boxelder Creek | 107 |
| CT-261 | 6S | 58E | 13 | a | 20 | UT East L O Creek | 13 |
| CT-262 | 6S | 58E | 14 | a | 3 | UT L O Creek | 2 |
| CT-291 | 3N | 59E | 3 | a | 30 | UT Little Beaver Creek | 20 |
| CT-293 | 3N | 59E | 5 | a | 8 | UT Little Beaver Creek | 5 |
| CT-294 | 3N | 59E | 6 | 0.4 | 50 | Groundwater | 22 |
| CT-301 | 2N | 57E | 28 | a | 390 | Little Beaver Creek | 260 |
| CT-310 | 1N | 59E | 35 | a | 45 | UT Boxelder Creek | 30 |
| CT-320 | 6S | 57E | 4 | 0.3 | 39 | Boxelder Creek | 17 |
| CT-330 | 2S | 60E | 7 | 1.0 | 130 | Boxelder Creek | 48 |
| CT-340 | 3N | 58E | 35 | a | 173 | HS Creek | 115 |
| CT-370 | 1S | 60E | 3 | 0.9 | 107 | Boxelder Creek | 39 |
| CT-380 | 4S | 59E | 3 | 0.2 | 36 | Boxelder Creek | 13 |
| TOTALS | | | | 26.3 | 4,684 | | 2,367 |
| **Daniels County Conservation District** | | | | | | | |
| DA-21 | 36N | 50E | 21 | a | 38 | S.F. Whitetail Cr. | 25 |
| DA-31 | 34N | 45E | 6 | 1.4 | 208 | Groundwater | 89 |
| DA-32 | 34N | 45E | 8 | 0.6 | 92 | Groundwater | 40 |
| DA-51 | 34N | 48E | 35 | 0.5 | 68 | Poplar River | 25 |
| DA-71 | 35N | 46E | 26 | 3.5 | 502 | Groundwater | 215 |
| DA-131 | 37N | 46E | 17 | a | 122 | UT M.F. Poplar | 81 |
| DA-151 | 35N | 48E | 20 | 2.2 | 316 | Groundwater | 135 |
| DA-152 | 35N | 48E | 16 | a | 9 | UT Poplar River | 6 |
| DA-153 | 35N | 48E | 29 | a | 119 | UT Poplar River | 79 |
| DA-161 | 35N | 45E | 26 | 0.2 | 32 | Police Creek | 11 |

| Project Number | Point of Diversion | | | Peak Flow (cfs) | Annual Use (af) | Water Source | Project Acres |
|---|---|---|---|---|---|---|---|
| | TWN | RGE | SEC | | | | |
| DA-181 | 37N | 46E | 9 | a | 120 | UT M.F. Poplar R. | 80 |
| DA-182 | 37N | 46E | 15 | a | 45 | UT M.F. Poplar R. | 30 |
| DA-211 | 37N | 48E | 19 | 0.8 | 82 | E.F. Poplar River | 35 |
| DA-221 | 35N | 46E | 22 | 2.2 | 320 | Spring, Olsen Coulee | 137 |
| DA-251 | 37N | 45E | 20 | 0.7 | 95 | Springs, Coal Cr. | 67 |
| DA-252 | 37N | 45E | 19 | 1.1 | 156 | Springs, Coal Cr. | 41 |
| DA-261 | 34N | 48E | 10 | 1.1 | 158 | Poplar River | 66 |
| DA-281 | 37N | 47E | 13 | 2.0 | 235 | Groundwater | 87 |
| DA-291 | 37N | 47E | 36 | a | 228 | UT E.F. Poplar R. | 152 |
| DA-341 | T35N | R48E | 5 | 0.6 | 84 | Poplar River | 36 |
| DA-371 | T37N | R45E | 27 | a | 3 | UT Butte Creek | 2 |
| TOTALS | | | | 16.9 | 3,032 | | 1,439 |
| **Liberty County Conservation District** | | | | | | | |
| LI-241 | T37N | R7E | 29 | 0.84 | 122 | Lost Coulee | 50 |
| **Little Beaver Conservation District** | | | | | | | |
| LB-011 | 11N | 60E | 25&30 | a | 116 | Rattlesnake Creek | 77 |
| LB-041 | 10N | 60E | 19 | a | 24 | Spring Creek | 16 |
| LB-061 | 5N | 60E | 19 | a | 90 | UT Little Beaver Creek | 60 |
| LB-063 | 5N | 60E | 29 | a | 14 | UT Little Beaver Creek | 9 |
| LB-083 | 4N | 59E | 33 | a | 75 | Bone Pile Creek | 50 |
| LB-121 | 9N | 61E | 4 | a | 146 | Beaver Creek | 97 |
| LB-141 | 4N | 61E | 10&15 | a | 218 | Mud Creek | 145 |
| LB-151 | 5N | 58E | 36 | a | 114 | UT Duck Creek | 76 |
| LB-161 | 9N | 60E | 2 | a | 408 | Fork of Beaver Creek | 272 |
| LB-171 | 10N | 61E | 7 | a | 45 | UT E.F. Beaver Creek | 30 |
| LB-172 | 10N | 61E | 18 | a | 18 | UT E.F. Beaver Creek | 12 |
| LB-181 | 7N | 61E | 5 | a | 17 | UT Dugout Creek | 11 |
| LB-182 | 8N | 61E | 34 | a | 38 | UT Dugout Creek | 25 |
| LB-191 | 10N | 60E | 8&9 | a | 225 | Beaver Creek and UT | 150 |
| Stockwater | — | — | — | a | 300 | — | |
| TOTALS | | | | | 1,848 | | 1,030 |
| **McCone Conservation District** | | | | | | | |
| MC-01 | 27N | 41E | 35 | 3.6 | 501 | Missouri River | 214 |
| MC-03 | 26N | 43E | 9 | 5.6 | 807 | Missouri River | 346 |
| MC-04 | 26N | 44E | 7 | 1.8 | 265 | Missouri River | 114 |
| MC-05 | 26N | 44E | 16 | 4.8 | 696 | Missouri River | 298 |
| MC-5A | 26N | 44E | 10 | 5.9 | 858 | Missouri River | 367 |
| MC-06 | 26N | 45E | 17 | 4.8 | 698 | Missouri River | 298 |
| MC-6A | 26N | 45E | 10 | 1.8 | 257 | Missouri River | 111 |
| MC-08 | 26N | 46E | 1 | 20.7 | 2,989 | Missouri River | 1,279 |
| MC-09 | 27N | 47E | 34 | 5.5 | 798 | Missouri River | 342 |
| MC-9A | 27N | 47E | 22 | 0.4 | 57 | Missouri River | 25 |
| MC-10 | 27N | 47E | 24 | 5.6 | 812 | Missouri River | 349 |
| MC-11 | 27N | 50E | 21 | 14.7 | 2,128 | Missouri River | 911 |
| MC-12 | 26N | 45E | 13 | 8.9 | 1,246 | Missouri River | 536 |
| MC-99 | 26N | 46E | 11 | 15.2 | 2,187 | Missouri River | 934 |
| TOTALS | | | | 99.3 | 14,299 | | 6,124 |
| **Richland County Conservation District** | | | | | | | |
| RI-01 | 27N | 51E | 21 | 26.0 | 3,667 | Missouri River | 1,550 |
| RI-02 | 26&27N | 51E | 26 | 4.6 | 651 | Missouri River | 278 |
| RI-03 | 27N | 51E | 24 | 13.2 | 1,896 | Missouri River | 810 |
| RI-04 | 27N | 52E | 31 | 3.3 | 472 | Missouri River | 202 |
| RI-05 | 27N | 52E | 21 | 8.8 | 1,230 | Missouri River | 526 |
| RI-06 | 27N | 52E | 23 | 6.8 | 972 | Missouri River | 416 |
| RI-07 | 28N | 53E | 31 | 19.5 | 2,441 | Missouri River | 1,029 |
| RI-08 | 27N | 53E | 3 | 5.3 | 658 | Missouri River | 277 |

| Project Number | Point of Diversion | | | Peak Flow (cfs) | Annual Use (af) | Water Source | Project Acres |
|---|---|---|---|---|---|---|---|
| | TWN | RGE | SEC | | | | |
| RI-09 | 27N | 54E | 6 | 15.1 | 2,188 | Missouri River | 935 |
| RI-10 | 27N | 54E | 12 | 11.1 | 1,519 | Missouri River | 643 |
| RI-11A | 28N | 55E | 34 | 3.1 | 441 | Missouri River | 189 |
| RI-11 | 27N | 55E | 1 | 11.1 | 1,606 | Missouri River | 686 |
| RI-12 | 27N | 56E | 3 | 11.8 | 1,635 | Missouri River | 782 |
| RI-13 | 27N | 57E | 28 | 6.0 | 835 | Missouri River | 399 |
| RI-14 | 26N | 58E | 6 | 17.0 | 2,128 | Missouri River | 1,003 |
| RI-15 | 26N | 59E | 5 | 23.3 | 3,010 | Missouri River | 1,416 |
| TOTALS | | | | 186.0 | 25,349 | | 11,141 |
| **Roosevelt Conservation District** | | | | | | | |
| CBI-1 | 27N | 49E | 13 | 11.8 | 2,121 | Missouri River | 929 |
| CBI-2 | 27N | 49E | 15 | 18.4 | 2,435 | Missouri River | 1,065 |
| CBI-3 | 27N | 49E | 13 | 29.2 | 4,190 | Missouri River | 1,911 |
| CBI-4 | 27N | 50E | 23 | 37.2 | 4,451 | Missouri River | 898 |
| CBI-5 | 27N | 51E | 18 | 6.7 | 570 | Missouri River | 182 |
| CBI-6 | 27N | 51E | 21 | 5.1 | 677 | Missouri River | 258 |
| CBI-7 | 27N | 51E | 25 | 22.2 | 2,191 | Missouri River | 784 |
| CBI-8 | 27N | 52E | 19 | 3.4 | 449 | Missouri River | 164 |
| CBI-9 | 27N | 52E | 16 | 5.6 | 646 | Missouri River | 238 |
| CBI-10 | 27N | 53E | 6 | 19.4 | 2,096 | Missouri River | 770 |
| CBI-11 | 27N | 53E | 2 | 40.8 | 4,084 | Missouri River | 1,640 |
| CBI-12 | 28N | 54E | 32 | 31.8 | 3,939 | Missouri River | 1,448 |
| CBI-13 | 27N | 56E | 4 | 231.6 | 33,157 | Missouri River | 9,175 |
| CBI-14 | 27N | 56E | 4 | 4.4 | 609 | Missouri River | 291 |
| CBI-15 | 27N | 55E | 1 | 15.2 | 1,504 | Missouri River | 618 |
| CBI-16 | 27N | 58E | 27 | 17.3 | 2,380 | Missouri River | 1,114 |
| CBI-17 | 27N | 57E | 28 | 9.8 | 1,351 | Missouri River | 627 |
| CBI-18 | 27N | 58E | 26 | 25.3 | 3,442 | Missouri River | 1,592 |
| CBI-19 | 27N | 58E | 26 | 9.0 | 1,217 | Missouri River | 549 |
| CBI-20 | 26N | 59E | 5 | 3.9 | 548 | Missouri River | 262 |
| CBI-21 | 26N | 59E | 15 | 10.8 | 1,058 | Missouri River | 464 |
| TOTALS | | | | 558.9 | 73,115 | | 24,979 |
| **Valley County Conservation District** | | | | | | | |
| VA-01 | 26N | 41E | 8 | 1.2 | 176 | Missouri River | 75 |
| VA-02 | 27N | 41E | 34 | 16.1 | 2,325 | Missouri River | 995 |
| VA-03 | 27N | 42E | 31 | 15.3 | 2,203 | Missouri River | 933 |
| VA-71 | 27&28N | 41E | 2 | 4.1 | 590 | Milk River | 253 |
| VA-171 | 35N | 39E | 36 | 2.3 | 337 | Well | 144 |
| VA-211 | 28N | 39E | 24 | 1.6 | 226 | Milk River | 98 |
| VA-231 | 27N | 41E | 25 | 5.2 | 745 | Missouri River | 320 |
| VA-261 | 27&28N | 41E | 1 | 2.5 | 365 | Milk River | 157 |
| VA-291 | 28N | 39E | 14 | 3.8 | 412 | Milk River | 151 |
| VA-521 | 28N | 41E | 30 | 2.0 | 289 | Milk River | 124 |
| TOTALS | | | | 54.1 | 7,668 | | 3,250 |
| **Wibaux Conservation District** | | | | | | | |
| WI-41 | 11N | 59E | 1 | a | 39 | UT Beaver Creek | 26 |
| WI-42 | 11N | 59E | 1 | a | 152 | UT Beaver Creek | 101 |
| WI-43 | 11N | 60E | 7 | a | 111 | UT Beaver Creek | 74 |
| WI-61 | 12N | 61E | 28 | a | 18 | UT Beaver Creek | 12 |
| WI-71 | 11N | 60E | 34 | a | 21 | UT Beaver Creek | 14 |
| WI-72 | 10N | 60E | 4 | a | 12 | UT Beaver Creek | 8 |
| WI-73 | 10N | 60E | 4&5 | a | 150 | E.F. Beaver Creek | 100 |
| WI-74 | 11N | 61E | 31 | a | 95 | E.F. Beaver Creek | 63 |
| WI-75 | 11N | 60E | 8 | a | 87 | UT Beaver Creek | 58 |
| WI-91 | 11N | 60E | 30 | a | 75 | Beaver Creek | 50 |
| WI-92 | 11N | 60E | 30 | a | 78 | Rattlesnake Creek | 52 |

| Project Number | Point of Diversion | | | Peak Flow (cfs) | Annual Use (af) | Water Source | Project Acres |
|---|---|---|---|---|---|---|---|
| | TWN | RGE | SEC | | | | |
| WI-93 | 11N | 59E | 36 | a | 9 | UT Beaver Creek | 6 |
| WI-121 | 13N | 59E | 35 | a | 41 | UT Beaver Creek | 27 |
| WI-151 | 14N | 60E | 21 | a | 120 | Yates Creek | 80 |
| WI-161 | 14N | 60E | 14 | a | 33 | UT Hay Creek | 22 |
| WI-162 | 14N | 60E | 24 | a | 9 | UT Yates Creek | 6 |
| WI-171 | 13N | 59E | 15 | a | 38 | Spring Creek | 25 |
| WI-181 | 10N | 60E | 1 | a | 90 | E.F. Beaver Creek and UT | 60 |
| WI-191 | 13N | 59E | 26 | a | 38 | UT Beaver Creek | 25 |
| WI-192 | 13N | 59E | 28 | a | 15 | UT Beaver Creek | 10 |
| WI-201 | 11N | 61E | 6 | a | 110 | Lamesteer Creek | 73 |
| WI-202 | 11N | 61E | 6 | a | 66 | UT Lamesteer Creek | 44 |
| WI-211 | 13N | 60E | 6 | a | 44 | UT Beaver Creek | 29 |
| WI-221 | 12N | 61E | 32 | a | 11 | UT Lamesteer Creek | 7 |
| WI-232 | 13N | 59E | 4 | a | 32 | UT Beaver Creek | 21 |
| WI-233 | 13N | 59E | 9 | a | 29 | UT Beaver Creek | 19 |
| WI-234 | 12N | 60E | 9 | a | 98 | Lamesteer Creek | 65 |
| WI-235 | 13N | 59E | 26 | a | 39 | UT Beaver Creek | 26 |
| WI-236 | 13N | 59E | 34 | a | 59 | UT Beaver Creek | 39 |
| WI-237 | 13N | 60E | 18&19 | a | 48 | Duck Creek | 32 |
| TOTALS | | | | | 1,767 | | 1,174 |

**Sheridan County Conservation District**

The Sheridan County Conservation District has applied to reserve 133,587 acre-feet/year of groundwater. This water would be allocated on a first-come, first-served basis to farmers and ranchers in the district. The district has identified 308 potential projects where the water could be used. The amounts applied for by groundwater source are as follows:

| Groundwater Source | Annual Diversion (af) |
|---|---|
| Westby-Dagmar Channel | 99,174.82 |
| Big Muddy Channel | 4,251 |
| Tributary Outwash Channels | 7,924 |
| Pre-Glacial Missouri Channel | 11,931.18 |
| Terrace Deposit Channel | 579 |
| Coalridge and Sand Creek Channels | 482 |
| Recharge Channels | 9,245 |
| TOTAL | 133,587 |

Sheridan County Conservation District Projects

| Project Number | –Point of Diversion– | | | Annual Diversion (af) | Project Acres |
|---|---|---|---|---|---|
| | TWN | RGE | SEC | | |
| 2.1 | 32 | 58 | 6 | 457 | 146 |
| 3.1 | 33 | 57 | 21 | 482 | 154 |
| 4.1 | 33 | 56 | 32 | 482 | 154 |
| 4.2 | 33 | 56 | 25 | 313 | 100 |
| 6.1 | 32 | 58 | 10 | 482 | 154 |
| 8.1 | 33 | 58 | 18 | 482 | 154 |
| 9.1 | 33 | 58 | 31 | 329 | 105 |
| 9.2 | 32 | 58 | 22 | 482 | 154 |
| 10.1 | 32 | 58 | 35 | 482 | 154 |
| 10.2 | 32 | 56 | 26 | 482 | 154 |
| 11.1 | 32 | 56 | 18 | 344 | 110 |
| 11.2 | 32 | 56 | 17 | 704 | 225 |
| 11.3 | 32 | 56 | 17 | 579 | 185 |
| 11.4 | 32 | 56 | 17 | 585 | 187 |
| 11.5 | 32 | 56 | 18 | 329 | 105 |
| 11.6 | 32 | 56 | 7 | 423 | 135 |
| 14.1 | 34 | 58 | 13 | 404 | 129 |
| 14.2 | 34 | 58 | 13 | 407 | 130 |
| 14.3 | 35 | 58 | 24 | 516 | 165 |

a - Water spreading projects where no peak flow has been requested
UT - Unnamed tributary
af - acre-feet
cfs - cubic feet per second

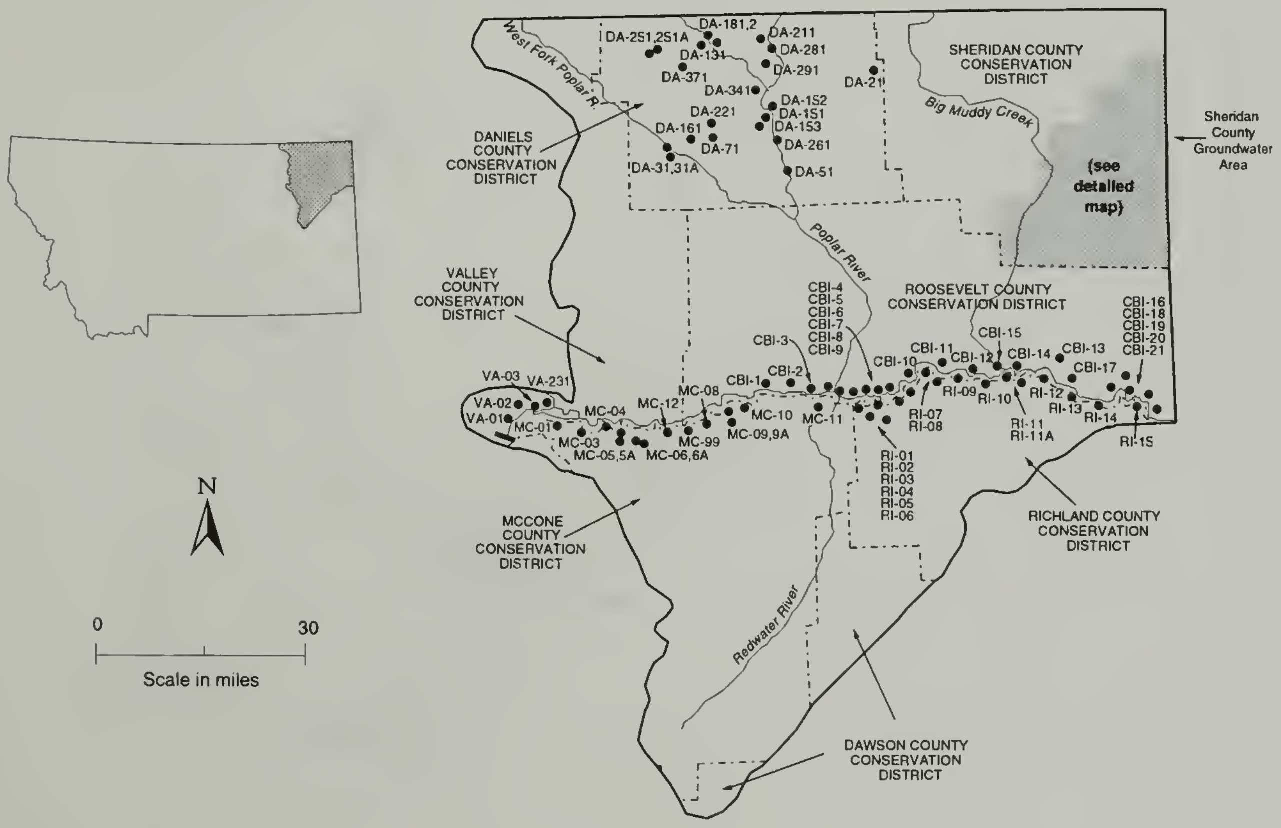
| Project Number | --Point of Diversion-- TWN | RGE | SEC | Annual Diversion (af) | Project Acres |
|---|---|---|---|---|---|
| 14.4 | 35 | 58 | 25 | 516 | 165 |
| 14.5 | 34 | 58 | 24 | 704 | 225 |
| 14.6 | 34 | 58 | 36 | 250 | 80 |
| 14.7 | 34 | 58 | 36 | 482 | 154 |
| 14.8 | 34 | 58 | 36 | 482 | 154 |
| 14.9 | 34 | 58 | 36 | 501 | 160 |
| 15.1 | 32 | 57 | 12 | 482 | 154 |
| 15.2 | 32 | 57 | 12 | 463 | 148 |
| 15.3 | 32 | 57 | 11 | 482 | 154 |
| 17.1 | 33 | 58 | 4 | 344 | 110 |
| 17.2 | 33 | 58 | 4 | 313 | 100 |
| 18.1 | 33 | 58 | 20 | 482 | 154 |
| 18.2 | 33 | 58 | 20 | 482 | 154 |
| 19.1 | 32 | 58 | 9 | 482 | 154 |
| 19.2 | 33 | 58 | 32 | 125 | 40 |
| 20.1 | 33 | 58 | 1 | 423 | 135 |
| 20.2 | 33 | 58 | 1 | 488 | 156 |
| 20.3 | 33 | 58 | 2 | 516 | 165 |
| 21.1 | 34 | 58 | 29 | 501 | 160 |
| 21.2 | 34 | 58 | 29 | 344 | 110 |
| 21.3 | 34 | 58 | 20 | 501 | 160 |
| 22.1 | 32 | 58 | 4 | 482 | 154 |
| 22.2 | 32 | 58 | 4 | 482 | 154 |
| 22.5 | 32 | 58 | 5 | 0.9 | NA |
| 23.1 | 33 | 58 | 1 | 532 | 170 |
| 23.2 | 33 | 58 | 12 | 432 | 138 |
| 23.3 | 33 | 58 | 12 | 250 | 80 |
| 23.4 | 33 | 58 | 14 | 482 | 154 |
| 23.5 | 33 | 58 | 2 | 551 | 176 |
| 26.1 | 31 | 57 | 2 | 482 | 154 |
| 28.1 | 32 | 56 | 29 | 460 | 147 |
| 28.2 | 32 | 56 | 29 | 463 | 148 |
| 28.3 | 32 | 56 | 27 | 470 | 150 |
| 30.1 | 31 | 56 | 33 | 460 | 147 |
| 30.2 | 31 | 56 | 33 | 463 | 148 |
| 30.3 | 31 | 56 | 28 | 482 | 154 |
| 30.4 | 31 | 56 | 33 | 463 | 148 |
| 30.5 | 31 | 56 | 33 | 482 | 154 |
| 30.6 | 31 | 56 | 34 | 482 | 154 |
| 30.7 | 31 | 56 | 34 | 482 | 154 |
| 30.8 | 31 | 56 | 32 | 482 | 154 |
| 30.9 | 31 | 56 | 31 | 482 | 154 |
| 30.10 | 31 | 56 | 31 | 404 | 129 |
| 32.1 | 33 | 58 | 21 | 501 | 160 |
| 32.2 | 33 | 58 | 21 | 501 | 160 |
| 32.3 | 33 | 58 | 30 | 235 | 75 |
| 33.1 | 32 | 57 | 1 | 501 | 160 |
| 34.1 | 32 | 57 | 21 | 482 | 154 |
| 34.2 | 32 | 57 | 16 | 482 | 154 |
| 34.3 | 32 | 57 | 21 | 482 | 154 |
| 35.1 | 34 | 57 | 23 | 482 | 154 |
| 36.1 | 32 | 57 | 2 | 482 | 154 |
| 37.1 | 32 | 57 | 26 | 485 | 155 |
| 38.1 | 33 | 58 | 20 | 482 | 154 |
| 38.2 | 33 | 58 | 11 | 482 | 154 |
| 38.3 | 33 | 58 | 12 | 460 | 147 |
| 39.1 | 33 | 58 | 29 | 250 | 80 |
| 39.2 | 32 | 57 | 20 | 482 | 154 |
| 39.3 | 32 | 57 | 20 | 463 | 148 |
| 39.4 | 32 | 57 | 19 | 482 | 154 |
| 39.5 | 32 | 57 | 20 | 463 | 148 |
| 39.6 | 33 | 57 | 13 | 463 | 148 |
| 40.1 | 33 | 58 | 20 | 482 | 154 |
| 40.2 | 33 | 58 | 28 | 457 | 146 |
| 40.3 | 32 | 58 | 7 | 460 | 148 |
| 40.4 | 33 | 58 | 19 | 360 | 115 |
| 42.1 | 32 | 56 | 19 | 501 | 160 |
| 42.2 | 32 | 56 | 28 | 482 | 154 |
| 42.3 | 32 | 56 | 28 | 482 | 154 |
| 42.4 | 32 | 56 | 19 | 501 | 160 |
| 42.5 | 32 | 56 | 27 | 344 | 110 |
| 44.1 | 31 | 56 | 32 | 482 | 154 |
| 44.2 | 31 | 56 | 32 | 482 | 154 |
| 44.3 | 31 | 56 | 32 | 429 | 137 |
| 45.1 | 31 | 56 | 27 | 391 | 125 |
| 45.2 | 31 | 56 | 27 | 482 | 154 |
| 45.3 | 31 | 56 | 28 | 482 | 154 |
| 47.1 | 31 | 57 | 2 | 482 | 154 |
| 47.2 | 31 | 57 | 3 | 482 | 154 |
| 47.3 | 31 | 57 | 3 | 250 | 80 |
| 47.4 | 31 | 57 | 9 | 751 | 240 |
| 47.5 | 31 | 57 | 9 | 376 | 120 |
| 54.1 | 33 | 58 | 17 | 482 | 154 |
| 57.1 | 32 | 56 | 26 | 482 | 154 |
| 58.1 | 32 | 56 | 24 | 482 | 154 |
| 59.1 | 31 | 56 | 28 | 485 | 155 |
| 59.2 | 31 | 56 | 25 | 432 | 138 |
| 59.3 | 31 | 56 | 25 | 457 | 146 |
| 59.4 | 31 | 56 | 24 | 482 | 154 |
| 59.5 | 31 | 56 | 24 | 460 | 147 |
| 59.6 | 31 | 57 | 30 | 460 | 147 |
| 59.9 | 31 | 57 | 30 | 1.8 | NA |
| 62.1 | 34 | 58 | 32 | 250 | 80 |
| 62.2 | 33 | 58 | 5 | 532 | 170 |
| 62.3 | 33 | 57 | 1 | 463 | 148 |
| 62.4 | 33 | 58 | 6 | 482 | 154 |
| 62.5 | 33 | 58 | 6 | 391 | 125 |
| 62.6 | 33 | 58 | 6 | 297 | 95 |
| 63.1 | 32 | 56 | 34 | 482 | 154 |
| 64.1 | 32 | 57 | 30 | 451 | 144 |
| 64.2 | 32 | 57 | 30 | 451 | 144 |
| 64.3 | 32 | 56 | 27 | 482 | 154 |
| 67.1 | 32 | 57 | 21 | 463 | 148 |
| 68.1 | 31 | 55 | 26 | 579 | 185 |
| 68.2 | 31 | 55 | 22 | 344 | 110 |
| 68.3 | 31 | 55 | 26 | 516 | 165 |
| 71.1 | 32 | 56 | 30 | 297 | 95 |
| 71.2 | 32 | 56 | 27 | 570 | 182 |
| 73.1 | 33 | 58 | 8 | 250 | 80 |
| 73.2 | 33 | 58 | 8 | 423 | 135 |
| 73.3 | 33 | 58 | 9 | 407 | 130 |
| 75.1 | 31 | 55 | 14 | 482 | 154 |
| 75.2 | 31 | 55 | 14 | 482 | 154 |
| 75.3 | 31 | 55 | 14 | 482 | 154 |
| 75.4 | 31 | 55 | 11 | 141 | 45 |
| 77.1 | 33 | 57 | 19 | 482 | 154 |
| 78.1 | 32 | 56 | 5 | 501 | 160 |
| 78.2 | 32 | 56 | 8 | 482 | 154 |
| 78.3 | 32 | 56 | 25 | 482 | 154 |
| 81.1 | 32 | 58 | 19 | 482 | 154 |

| Project Number | –Point of Diversion– TWN | RGE | SEC | Annual Diversion (af) | Project Acres |
|---|---|---|---|---|---|
| 81.2 | 32 | 58 | 21 | 482 | 154 |
| 81.3 | 32 | 58 | 21 | 463 | 148 |
| 81.4 | 32 | 58 | 20 | 482 | 154 |
| 81.5 | 32 | 58 | 20 | 219 | 70 |
| 82.1 | 32 | 57 | 1 | 470 | 150 |
| 82.2 | 32 | 57 | 1 | 501 | 160 |
| 82.3 | 33 | 57 | 21 | 482 | 154 |
| 83.1 | 33 | 57 | 26 | 482 | 154 |
| 84.1 | 32 | 57 | 14 | 376 | 120 |
| 84.2 | 32 | 57 | 29 | 250 | 80 |
| 85.1 | 32 | 58 | 30 | 401 | 128 |
| 85.2 | 32 | 58 | 30 | 407 | 130 |
| 85.3 | 32 | 58 | 30 | 376 | 120 |
| 85.4 | 32 | 58 | 27 | 438 | 140 |
| 85.5 | 32 | 58 | 28 | 460 | 147 |
| 85.6 | 32 | 58 | 28 | 460 | 147 |
| 85.7 | 32 | 58 | 29 | 482 | 154 |
| 85.8 | 32 | 58 | 29 | 438 | 140 |
| 85.9 | 32 | 58 | 29 | 482 | 154 |
| 85.10 | 32 | 57 | 25 | 376 | 120 |
| 85.11 | 32 | 57 | 26 | 203 | 65 |
| 85.12 | 32 | 57 | 26 | 250 | 80 |
| 85.13 | 32 | 56 | 26 | 482 | 154 |
| 86.1 | 32 | 56 | 2 | 516 | 165 |
| 87.1 | 33 | 58 | 13 | 313 | 100 |
| 87.2 | 33 | 58 | 13 | 313 | 100 |
| 88.1 | 33 | 58 | 13 | 482 | 154 |
| 88.2 | 33 | 58 | 24 | 344 | 110 |
| 88.3 | 33 | 58 | 13 | 482 | 154 |
| 89.1 | 33 | 58 | 12 | 516 | 165 |
| 89.2 | 33 | 58 | 12 | 407 | 130 |
| 90.1 | 34 | 58 | 1 | 532 | 170 |
| 90.2 | 34 | 58 | 28 | 482 | 154 |
| 90.3 | 34 | 58 | 21 | 482 | 154 |
| 90.4 | 34 | 58 | 28 | 482 | 154 |
| 90.5 | 34 | 58 | 1 | 532 | 170 |
| 90.6 | 34 | 58 | 21 | 407 | 130 |
| 90.7 | 34 | 58 | 34 | 482 | 154 |
| 92.1 | 32 | 58 | 21 | 470 | 150 |
| 94.1 | 33 | 58 | 32 | 200 | 64 |
| 94.2 | 32 | 58 | 10 | 376 | 120 |
| 94.3 | 32 | 58 | 2 | 516 | 165 |
| 94.4 | 33 | 58 | 8 | 482 | 154 |
| 100.1 | 32 | 57 | 12 | 482 | 154 |
| 100.2 | 32 | 57 | 12 | 482 | 154 |
| 100.3 | 32 | 57 | 11 | 482 | 154 |
| 100.4 | 32 | 57 | 10 | 203 | 65 |
| 100.5 | 32 | 57 | 11 | 404 | 129 |
| 103.1 | 36 | 58 | 35 | 482 | 154 |
| 103.2 | 36 | 58 | 35 | 391 | 125 |
| 104.1 | 34 | 58 | 10 | 438 | 140 |
| 105.1 | 33 | 58 | 35 | 482 | 154 |
| 105.2 | 33 | 58 | 34 | 288 | 92 |
| 105.3 | 32 | 58 | 1 | 482 | 154 |
| 105.4 | 33 | 58 | 35 | 401 | 128 |
| 105.5 | 33 | 58 | 35 | 482 | 154 |
| 105.6 | 33 | 58 | 35 | 250 | 80 |
| 106.1 | 34 | 58 | 22 | 219 | 70 |
| 106.2 | 34 | 58 | 27 | 460 | 147 |
| 106.3 | 34 | 58 | 27 | 363 | 116 |
| 108.1 | 35 | 58 | 35 | 482 | 154 |
| 110.1 | 35 | 58 | 26 | 482 | 154 |
| 112.1 | 31 | 56 | 27 | 482 | 154 |
| 112.2 | 31 | 56 | 35 | 460 | 147 |
| 112.3 | 31 | 56 | 35 | 344 | 110 |
| 115.1 | 33 | 58 | 26 | 516 | 165 |
| 116.1 | 32 | 58 | 10 | 482 | 154 |
| 116.2 | 32 | 58 | 22 | 532 | 170 |
| 116.3 | 32 | 58 | 10 | 404 | 129 |
| 116.4 | 32 | 58 | 20 | 407 | 130 |
| 118.1 | 36 | 58 | 33 | 423 | 135 |
| 118.2 | 36 | 58 | 27 | 376 | 120 |
| 118.3 | 36 | 58 | 28 | 313 | 100 |
| 122.1 | 36 | 57 | 35 | 460 | 147 |
| 122.2 | 32 | 58 | 5 | 482 | 154 |
| 123.1 | 33 | 58 | 30 | 463 | 148 |
| 123.2 | 33 | 57 | 25 | 463 | 148 |
| 124.1 | 34 | 58 | 1 | 482 | 154 |
| 124.2 | 34 | 58 | 1 | 482 | 154 |
| 124.3 | 35 | 58 | 24 | 482 | 154 |
| 124.4 | 35 | 58 | 24 | 482 | 154 |
| 127.1 | 36 | 58 | 36 | 407 | 130 |
| 127.2 | 36 | 58 | 36 | 370 | 118 |
| 129.1 | 33 | 58 | 36 | 457 | 146 |
| 129.2 | 33 | 58 | 36 | 438 | 140 |
| 129.3 | 33 | 58 | 36 | 401 | 128 |
| 130.1 | 36 | 58 | 32 | 454 | 145 |
| 130.2 | 36 | 58 | 32 | 501 | 160 |
| 130.3 | 33 | 57 | 11 | 482 | 154 |
| 130.4 | 33 | 57 | 11 | 423 | 135 |
| 131.1 | 35 | 58 | 9 | 482 | 154 |
| 131.2 | 35 | 58 | 9 | 401 | 128 |
| 133.1 | 35 | 58 | 3 | 432 | 138 |
| 133.2 | 36 | 58 | 34 | 444 | 142 |
| 133.3 | 35 | 58 | 10 | 463 | 148 |
| 134.1 | 31 | 57 | 1 | 181 | 58 |
| 134.2 | 32 | 57 | 34 | 282 | 90 |
| 134.3 | 32 | 57 | 35 | 560 | 179 |
| 134.4 | 32 | 57 | 35 | 501 | 160 |
| 135.1 | 34 | 58 | 12 | 482 | 154 |
| 135.2 | 34 | 58 | 12 | 313 | 100 |
| 135.3 | 34 | 58 | 1 | 250 | 80 |
| 135.4 | 35 | 58 | 2 | 482 | 154 |
| 135.5 | 35 | 58 | 2 | 429 | 137 |
| 135.6 | 35 | 58 | 10 | 376 | 120 |
| 137.1 | 33 | 58 | 30 | 482 | 154 |
| 138.1 | 34 | 58 | 12 | 501 | 160 |
| 138.2 | 34 | 58 | 13 | 482 | 154 |
| 138.3 | 34 | 58 | 13 | 626 | 200 |
| 143.1 | 32 | 58 | 20 | 482 | 154 |
| 143.2 | 32 | 56 | 20 | 463 | 148 |
| 143.3 | 32 | 56 | 20 | 482 | 154 |
| 144.1 | 32 | 56 | 25 | 235 | 75 |
| 145.1 | 34 | 58 | 32 | 269 | 86 |
| 145.2 | 34 | 58 | 31 | 316 | 101 |
| 145.3 | 34 | 58 | 31 | 432 | 138 |
| 146.1 | 33 | 57 | 1 | 463 | 148 |
| 146.2 | 34 | 57 | 36 | 432 | 138 |
| 147.1 | 33 | 58 | 29 | 376 | 120 |
| 148.1 | 36 | 58 | 34 | 532 | 170 |
| 148.2 | 35 | 58 | 3 | 482 | 154 |
| 148.3 | 35 | 58 | 3 | 463 | 148 |
| 150.1 | 32 | 56 | 28 | 457 | 146 |
| 150.2 | 32 | 56 | 29 | 507 | 162 |
| 151.1 | 32 | 58 | 15 | 482 | 154 |
| 151.2 | 32 | 58 | 15 | 482 | 154 |

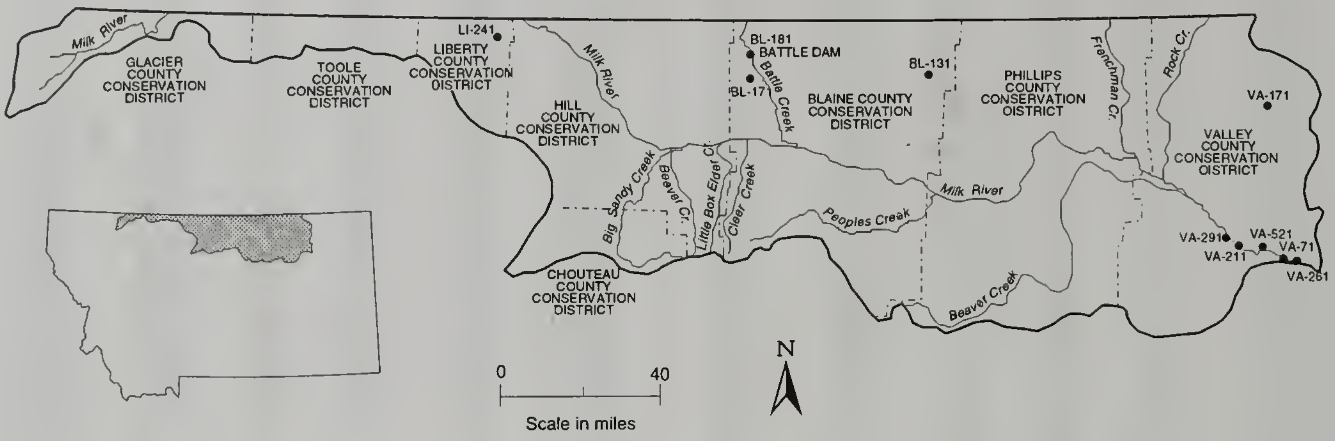
| Project Number | --Point of Diversion-- TWN | RGE | SEC | Annual Diversion (af) | Project Acres |
|---|---|---|---|---|---|
| 152.1 | 35 | 58 | 35 | 250 | 80 |
| 155.1 | 35 | 58 | 31 | 626 | 75 |
| 156.1 | 34 | 58 | 2 | 482 | 154 |
| 156.2 | 34 | 58 | 2 | 235 | 75 |
| 156.3 | 35 | 58 | 26 | 250 | 80 |
| 157.1 | 34 | 58 | 35 | 463 | 148 |
| 157.2 | 34 | 58 | 35 | 363 | 116 |
| 159.1 | 32 | 55 | 24 | 376 | 120 |
| 160.1 | 31 | 55 | 34 | 244 | 78 |
| 161.1 | 32 | 56 | 29 | 482 | 154 |
| 161.2 | 32 | 56 | 29 | 250 | 80 |
| 162.1 | 35 | 58 | 24 | 354 | 113 |
| 163.1 | 31 | 56 | 25 | 250 | 80 |
| 163.2 | 31 | 56 | 26 | 188 | 60 |
| 164.1 | 34 | 58 | 30 | 429 | 137 |
| 165.1 | 34 | 58 | 24 | 429 | 137 |
| 165.2 | 34 | 58 | 24 | 376 | 120 |
| 166.1 | 34 | 58 | 22 | 488 | 156 |
| 166.2 | 34 | 58 | 15 | 423 | 135 |
| 168.1 | 33 | 56 | 27 | 482 | 154 |
| 170.1 | 33 | 58 | 23 | 463 | 148 |
| 170.2 | 33 | 58 | 24 | 482 | 154 |
| 171.1 | 35 | 58 | 4 | 260 | 83 |
| 171.2 | 35 | 58 | 4 | 288 | 92 |
| 176.1 | 33 | 57 | 25 | 482 | 154 |
| 177.1 | 34 | 58 | 23 | 423 | 135 |
| 179.1 | 34 | 58 | 15 | 482 | 154 |
| 179.2 | 34 | 58 | 15 | 482 | 154 |
| 179.3 | 35 | 58 | 25 | 482 | 154 |
| 179.4 | 35 | 58 | 25 | 482 | 154 |
| 179.5 | 34 | 58 | 15 | 482 | 154 |
| 179.6 | 35 | 58 | 25 | 482 | 154 |
| 179.7 | 34 | 58 | 12 | 482 | 154 |
| 179.8 | 34 | 58 | 11 | 482 | 154 |
| 179.9 | 34 | 58 | 11 | 482 | 154 |
| 179.10 | 35 | 58 | 36 | 482 | 154 |
| 179.11 | 35 | 58 | 36 | 482 | 154 |
| 179.12 | 35 | 58 | 36 | 482 | 154 |
| 179.13 | 35 | 58 | 36 | 482 | 154 |
| 179.14 | 34 | 58 | 12 | 482 | 154 |
| 179.15 | 34 | 58 | 11 | 360 | 115 |
| 180.1 | 33 | 57 | 24 | 482 | 154 |
| 180.2 | 33 | 57 | 15 | 432 | 138 |

SOURCES:
Blaine County Conservation District 1991
Carter County Conservation District 1991
Daniels County Conservation District 1991
Liberty County Conservation District 1991
Little Beaver Conservation District 1991
McCone Conservation District 1991
Richland County Conservation District 1991
Roosevelt Conservation District 1991
Sheridan County Conservation District 1991
Valley County Conservation District 1991
Wibaux Conservation District 1991

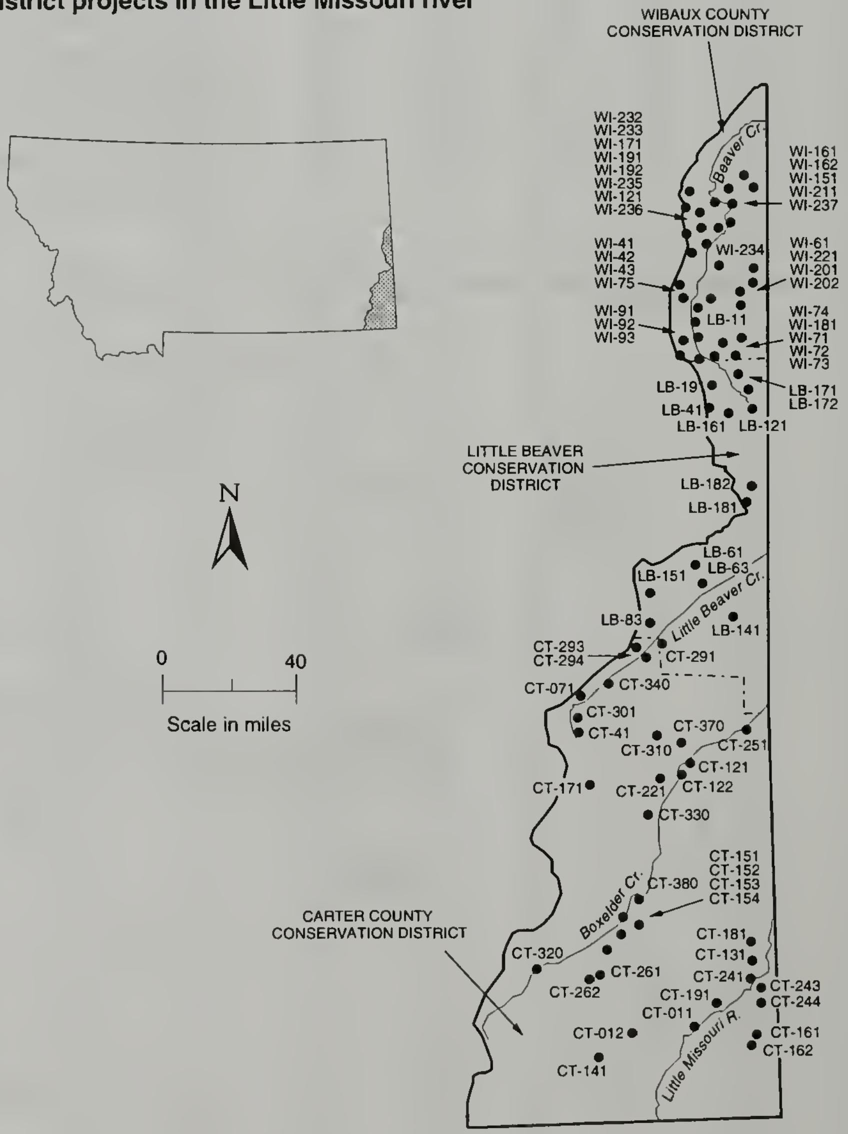
**Map 3-2. Proposed conservation district projects in the Lower Missouri River Subbasin**



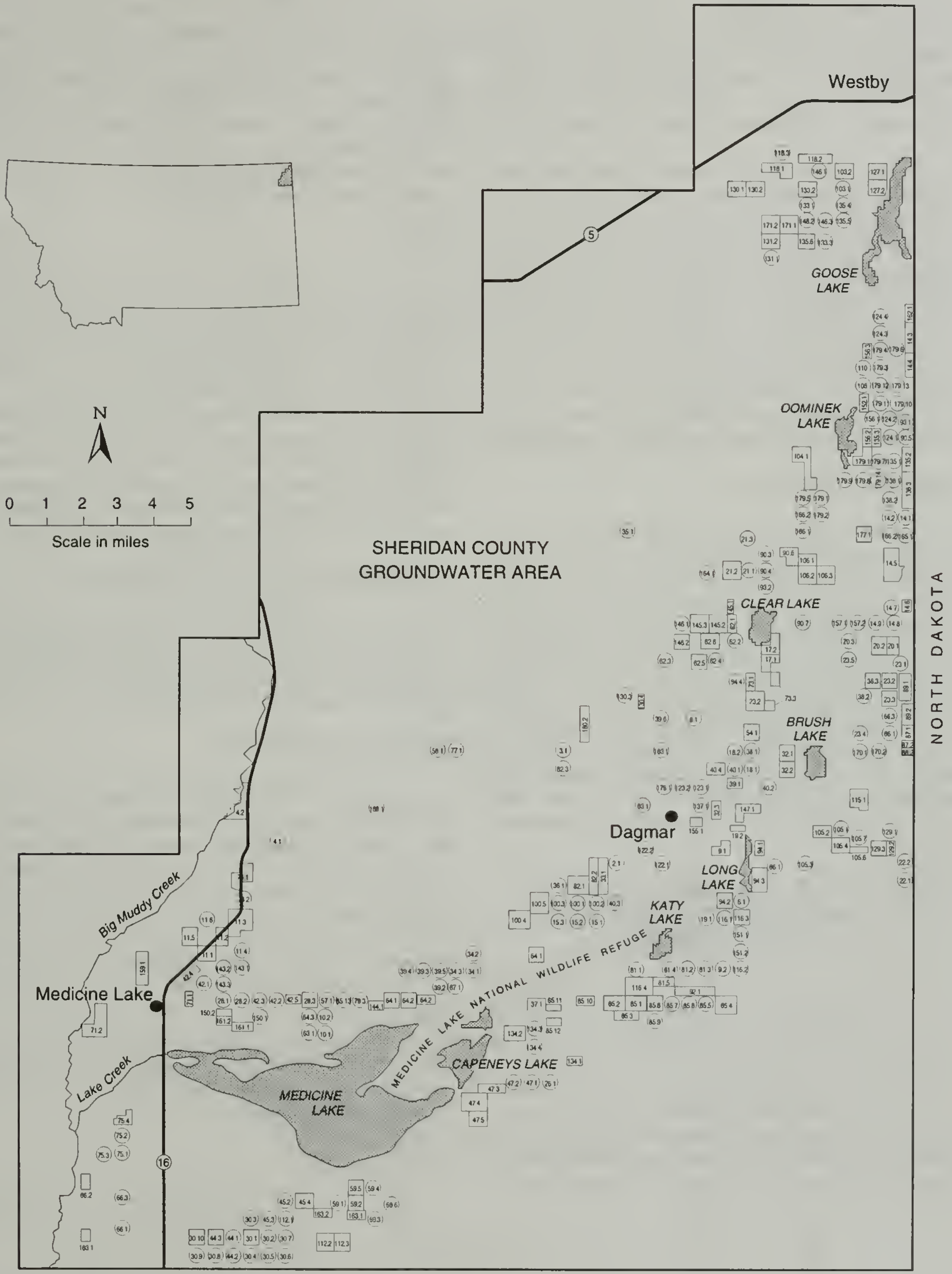
Map 3-3. Proposed conservation district projects in the Milk River Subbasin


Milk River
GLACIER COUNTY CONSERVATION DISTRICT
TOOLE COUNTY CONSERVATION DISTRICT
LI-241
LIBERTY COUNTY CONSERVATION DISTRICT
Milk River
HILL COUNTY CONSERVATION DISTRICT
Big Sandy Creek
Beaver Cr.
Little Box Elder Cr.
Clear Creek
CHOUTEAU COUNTY CONSERVATION DISTRICT
BL-181
BATTLE DAM
BL-17
Battle Creek
BLAINE COUNTY CONSERVATION DISTRICT
BL-131
Peoples Creek
Milk River
PHILLIPS COUNTY CONSERVATION DISTRICT
Frenchman Cr.
Rock Cr.
Beaver Creek
VA-171
VALLEY COUNTY CONSERVATION DISTRICT
VA-291
VA-211
VA-521
VA-71
VA-261
0
40
Scale in miles
N

Map 3-4. Proposed conservation district projects in the Little Missouri river Subbasin



**Map 3-5. Groundwater development projects proposed by the Sheridan County Conservation District**



Stream gauge data were used to calculate available water for some projects, while flows were estimated in many ungauged watersheds (DNRC 1990). Groundwater availability was determined using available data and knowledge of local aquifer characteristics and, in the case of the Sheridan County Conservation District, a report by the Montana Bureau of Mines and Geology (Donovan 1986).

For land where the conservation districts found water to be physically available, engineering analyses were made of potential irrigation systems, cost estimates were prepared, and crop irrigation requirements were determined. The suitability of soils for irrigation at the project sites was also considered in the screening process. Lastly, the economic and financial feasibilities of the proposed development plans were assessed. Projects not eliminated in any stage of this screening process were used as the basis for determining the amount of water to be requested in the conservation district applications.

### PUBLIC INTEREST

The conservation districts consider the reservation requests to be in the public interest for three reasons. First, irrigation is defined as a beneficial water use in Montana (§85-2-102, MCA), and in the past, the Montana Legislature directed DNRC to recognize the primary role of agriculture in the state's economy when allocating water development funds. Second, the reservation applications serve to identify consumptive uses for currently unappropriated water. Third, the development of future irrigation projects in the conservation districts would bring economic benefits to farmers, ranchers, and other people in the counties and surrounding communities.

## MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS APPLICATION

DFWP's application is intended to maintain water levels adequate for fish, wildlife, and recreation on 18 streams. Some streams where reservations are requested have been divided into segments or "reaches" with the reservation requests varying by reach. Reservation requests vary for different seasons of the year on many streams and reaches. The individual reservation requests are summarized in Table 3-2 and shown on Maps 3-6 through 3-8.

### PURPOSE

As stated by DFWP, the purpose of its reservation is to reserve flows for existing and future beneficial uses so as to maintain a minimum flow, level, or quality of water by month and throughout the year. The water would be reserved to provide habitat for fish and wildlife, to benefit the public for recreational uses, to contribute to and maintain a clean, healthful and desirable environment, and to sustain adequate levels of water quality.

### NEED

Under Montana statutes, an instream water right for fish, wildlife, and recreational purposes can be obtained only by applying for a reservation and not by petition or application for a water use permit. DFWP believes that if the water requested is not reserved now and is instead allowed to be appropriated for consumptive use, fish, wildlife and recreational resources would be deprived of the water. DFWP maintains that the reservation of instream flows is necessary to maintain quality angling and other water-oriented recreational opportunities.

### DETERMINATION OF AMOUNT

DFWP used several methods to determine the amount of its instream flow requests. A thorough discussion of these methods is presented in DFWP's application and Appendix C.

### PUBLIC INTEREST

According to DFWP, the reservation requests are in the public interest for the following reasons: (1) the perpetuation of fish and wildlife resources for current and future use is in the public interest, (2) the reservations would prevent the gradual depletion of streamflows and the diminishment of recreational use by the public, (3) the reservations would perpetuate fish and wildlife resources for current and future use by the public, (4) the reserved flows would help to maintain water quality, contributing to a clean and healthful environment for the citizens of the state and nation, and (5) the reservations would contribute to the protection and continued use of existing water rights.

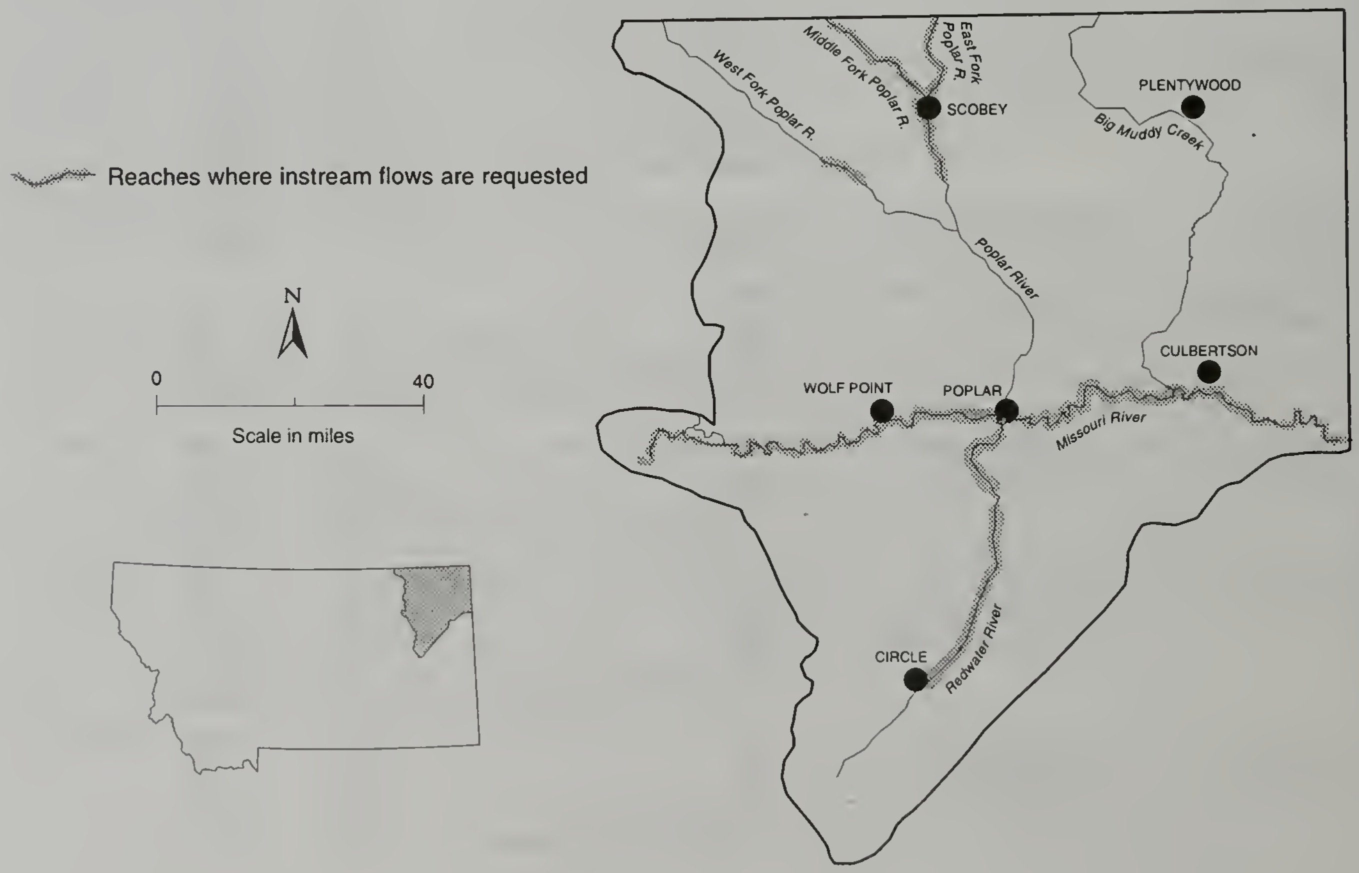
**Table 3-2. Montana Department of Fish, Wildlife and Parks Instream Flow Requests**

| Stream | Reach | Dates Requested | —Amount Requested— | | |
|---|---|---|---|---|---|
| | | | (cfs) | (af) | (af/yr) |
| **Milk River Subbasin** | | | | | |
| Battle Creek | International boundary to mouth | Jan., Feb., Mar., Dec., | 2.0 | 480 | 15,078 |
| | | Apr. through Nov. | 5.0 | 2,420 | |
| | | Channel Maintenance Flows | 1,970* | 12,178 | |
| Beaver Creek (Hill County) | Reservation boundary to Beaver Creek Reservoir | Year-round | 7.0 | 5,068 | 5,068 |
| Beaver Creek #1 (Phillips Co.) | Headwaters to reservation boundary | Year-round | 0.2 | 145 | 145 |
| Beaver Creek #2 (Phillips County) | Highway 191 to mouth | Jan., Feb., Mar., Dec. | 7.0 | 1,679 | 15,950 |
| | | Apr. through Nov. | 11.0 | 5,324 | |
| | | Channel Maintenance Flows | 1,160* | 8,947 | |
| Clear Creek | Headwaters to Clear Creek Road | Year-round | 5.0 | 3,620 | 3,620 |
| Frenchman River | International boundary to mouth | Jan., Feb., Mar., Dec. | 2.0 | 480 | 25,314 |
| | | Apr. through Nov. | 5.0 | 2,420 | |
| | | Channel Maintenance Flows | 2,050* | 22,414 | |
| Little Box Elder Creek | Headwaters to Clear Creek Road | Year-round | 1.0 | 724 | 724 |
| Peoples Creek | Headwaters to Barney Olson Road | Year-round | 1.0 | 724 | 724 |
| Rock Creek | International boundary to mouth | Jan., Feb., Mar., Dec. | 2.0 | 480 | 27,600 |
| | | Apr. through Nov. | 8.0 | 3,872 | |
| | | Channel Maintenance Flows | 2,180* | 23,248 | |
| Missouri River #7 | Fort Peck Dam to Milk River | April 1-May 10 | 7,800 | 618,843 | 5,620,361 |
| | | May 11-June 30 | 11,000 | 1,112,727 | |
| | | July 1-Sept. 30 | 7,800 | 1,423,338 | |
| | | Oct. 1-Feb. 28 | 7,000 | 2,096,528 | |
| | | March 1-March 31 | 6,000 | 368,925 | |
| Missouri River #8 | Milk River to state line | May 11-June 30 | 11,500 | 1,163,305 | 5,522,972 |
| | | July 1-May 10 | 7,000 | 4,359,667 | |
| East Fork Poplar River | International boundary to Middle Fork | Jan., Feb., Mar., Dec. | 3.0 | 719 | 6,870 |
| | | April | 15 | 893 | |
| | | May | 10 | 615 | |
| | | June through Nov. | 4 | 1,452 | |
| | | Channel Maintenance Flows | 540* | 3,191 | |
| Middle Fork Poplar River | International boundary to East Fork | Jan., Feb., Mar., Dec. | 1.0 | 239 | 10,685 |
| | | April | 30.0 | 1,785 | |
| | | May | 20.0 | 1,230 | |
| | | June through Nov. | 2.0 | 726 | |
| | | Channel Maintenance Flows | 1,000* | 6,705 | |
| Poplar River | Junction of Middle and East Forks to reservation boundary | Jan., Feb., Mar., Dec. | 8.0 | 1,920 | 21,207 |
| | | April | 70.0 | 4,165 | |
| | | May | 50.0 | 3,074 | |
| | | June through Nov. | 11.0 | 3,993 | |
| | | Channel Maintenance Flows | 1,210* | 8,055 | |
| West Fork Poplar River | County bridge south of Peerless to reservation boundary | Jan., Feb., Mar., Dec. | 3.0 | 719 | 13,121 |
| | | April | 30.0 | 1,785 | |
| | | May | 20.0 | 1,230 | |
| | | June through Nov. | 4.0 | 1,452 | |
| | | Channel Maintenance Flows | 1,190* | 7,935 | |

| | | | —Amount Requested— | | |
|---|---|---|---|---|---|
| **Stream** | **Reach** | **Dates Requested** | **(cfs)** | **(af)** | **(af/yr)** |
| **Lower Missouri River Subbasin** | | | | | |
| Redwater River #1 | Circle to East Redwater Creek | Jan., Feb., Mar., Dec. | 2.0 | 480 | 12,792 |
| | | Apr. through Nov. | 3.0 | 1,452 | |
| | | Channel Maintenance Flows | 1,730* | 10,860 | |
| Redwater River #2 | East Redwater Creek to mouth | Jan., Feb., Mar., Dec. | 2.0 | 480 | 15,060 |
| | | Apr. through Nov. | 4.0 | 1,936 | |
| | | Channel Maintenance Flows | 2,010* | 12,644 | |
| **Little Missouri River Subbasin** | | | | | |
| Beaver Creek (Wibaux County) | Lamesteer Creek to state line | Jan., Feb., Mar., Dec. | 1.0 | 239 | 7,984 |
| | | Apr. through Nov. | 0.7 | 340 | |
| | | Channel Maintenance Flows | 1,050* | 7,405 | |
| Boxelder Creek | One mile west of Belltower to state line | Jan., Feb., Mar., Dec. | 4.0 | 960 | 20,682 |
| | | Apr. through Nov. | 7.0 | 3,388 | |
| | | Channel Maintenance Flows | 1,820* | 16,334 | |
| Little Beaver Creek | Russell Creek to state line | Year-round | 3.0 | 2,171 | 17,895 |
| | | Channel Maintenance Flows | 2,050* | 15,724 | |
| Little Missouri River | Montana-Wyoming border to Montana-South Dakota border | Jan., Feb., Mar., Dec. | 5.0 | 1,199 | 32,562 |
| | | Apr. through Nov. | 8.0 | 3,872 | |
| | | Channel Maintenance Flows | 2,540* | 27,491 | |

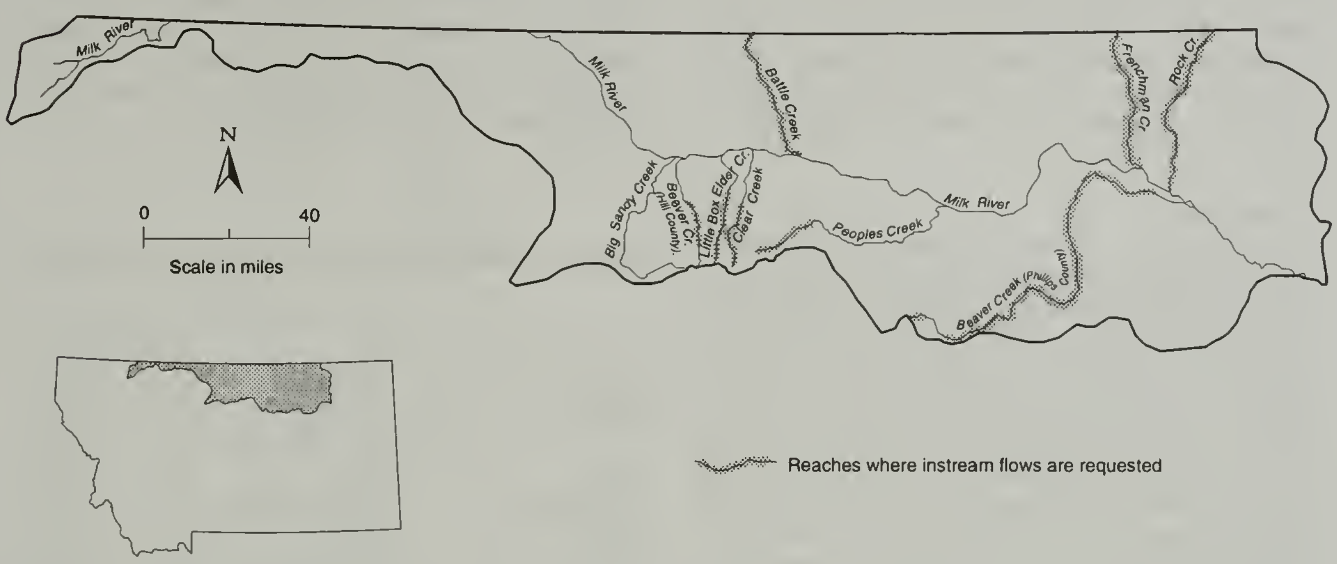
*Channel maintenance flow request are for varying amounts over a 13- to 21-day period; only the peak daily request is included here.
af - acre-feet af/yr - acre-feet per yearcfs - cubic feet per second
Source: Department of Fish, Wildlife and Parks 1991

**Map 3-6. Location of instream flow requests in the Lower Missouri River subbasin**

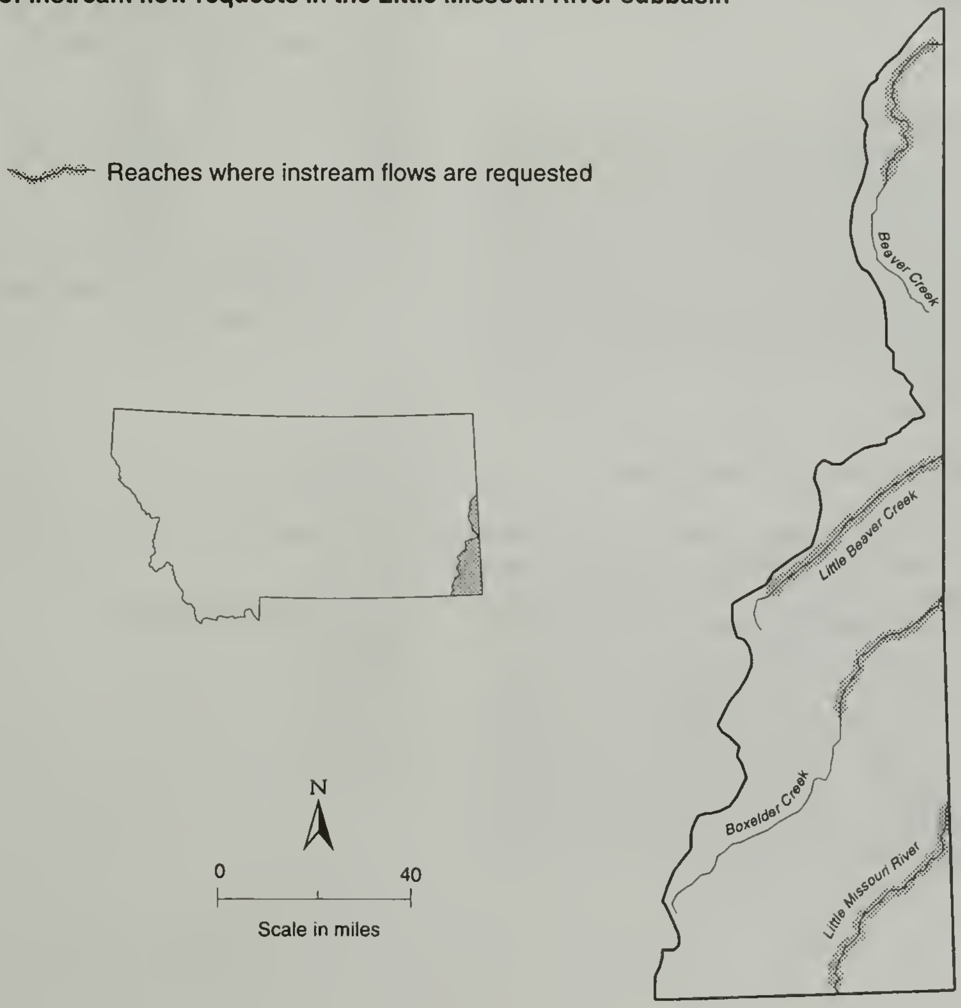


**Map 3-7. Location of instream flow requests in the Milk River subbasin**

**Map 3-7. Location of instream flow requests in the Milk River subbasin**



**Map 3-8. Location of instream flow requests in the Little Missouri River subbasin**



## MUNICIPAL APPLICATIONS

Thirteen municipalities and one water and sewer district have applied to reserve water in the basin for domestic, community, and commercial needs. The requests encompass a variety of projects in the individual communities and pertain to both surface water and groundwater sources. These reservation requests are summarized in Table 3-3 and shown on Map 3-9.

### PURPOSE

The purpose of the municipal reservation requests is to reserve water for future municipal uses, including domestic water supplies, irrigation of lawns, parks and city grounds, and commercial and industrial uses. Securing water reservations would help ensure that water would be available for future growth. In some instances, communities are requesting new water supplies due to problems with present sources, such as poor water quality and unreliable supply. The beneficiaries of municipal reservations would be the residents and businesses in the communities served by the municipal water supply systems.

### NEED

Because the municipalities and Hill County Water District feel that water use in the Missouri River basin is continually increasing, they believe they need to reserve water to accommodate future growth. A reservation is the only means of obtaining water for needs that will occur in the future. The possibility of future conflicts with other water users such as downstream states and the federal government is a further reason for communities and rural water systems to obtain reservations.

### DETERMINATION OF AMOUNT

Although different municipalities used different methods for determining how much water to request, some general procedures were used by all the municipal and water district applicants. Each town or water district forecast its future service area population to the year 2035 and estimated the amount of water used per person. In many cases, the needs of service areas outside the city also were taken into account. Potential sources and storage, supply, treatment, distribution, and discharge facilities were identified and evaluated in each community's application.

### PUBLIC INTEREST

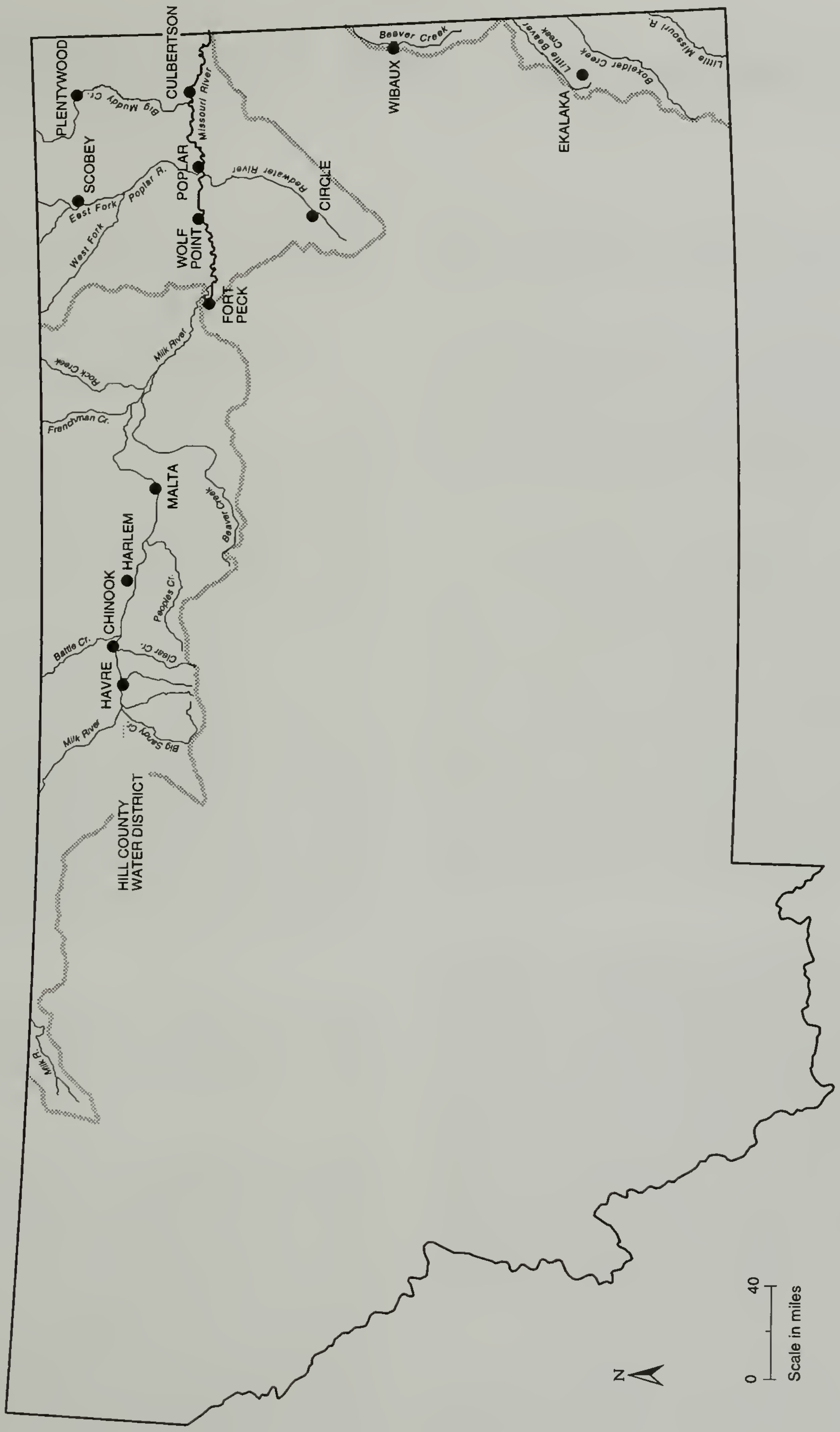
According to the municipalities and Hill County Water District, the reservation requests are in the public interest for two primary reasons. First, there is constitutional and legislative support for reservation and subsequent acquisition of water for municipal and rural domestic use. Second, it is essential that cities and rural areas secure an adequate, stable water supply for future development.

**Table 3-3. Reservation requested by municipalities**

| MUNICIPALITY | SOURCE | —AMOUNT— CFS | AF/Y |
|---|---|---|---|
| Chinook | (1) well | 0.73 | 200 |
| | (2) Milk River | [b] | 600 |
| Circle | well | 0.57 | 78 |
| Culbertson[a] | Missouri River | 0.62 | 365 |
| Ekalaka | wells | 0.10 | 20 |
| Fort Peck | Missouri River | 0.30 | 100 |
| Harlem | (1) well | 0.73 | 200 |
| | (2) Milk River | [b] | 365 |
| Havre | wells | 2.2 | 475 |
| Hill Co. Water District | Marias River | [b] | 652 |
| Malta | well | 0.63 | 137 |
| Plentywood | well | 1.04 | 235 |
| Poplar | wells | 2.08 | 448 |
| Scobey | well | 1.04 | 168 |
| Wibaux | wells | 0.42 | 70.6 |
| Wolf Point | wells | 2.1 | 504 |

[a] Also includes water for proposed water and sewer district
[b] No peak flow rate request

Sources:
Chinook 1991
Circle 1991
Culbertson 1991
Ekalaka 1991
Fort Peck 1991
Harlem 1991
Havre 1991
Hill County Water District 1991
Malta 1991
Plentywood 1991
Poplar 1991
Scobey 1991
Wibaux 1991
Wolf Point 1991



Map 3-9. Municipalities and water districts that have applied to reserve water in the basin

## CHAPTER FOUR

# AFFECTED ENVIRONMENT

This chapter includes a description of the existing environment within the Missouri River basin below Fort Peck Dam—the region that would be affected by the requested reservations.

## WATER QUANTITY AND DISTRIBUTION

The following section describes the various factors that influence natural flows on streams where reservations have been requested. The existing streamflow conditions for each of the subbasins are described. DNRC also developed computer models to examine water availability in each of the subbasins. The models are explained in more detail in Appendix D.

### EXISTING FLOW PATTERNS

The natural streamflow patterns for the subbasins in the eastern part of the state are seasonal, with spring rains and prairie snowmelt contributing to a springtime peak flow in March or April. Flows diminish during the summer, fall, and winter, with occasional high flows from thunderstorms or winter snowmelt during warm spells. Some streams flow throughout the year due to groundwater inflows.

Natural flow patterns are altered by human activities—primarily irrigation, reservoir operations, and, to a smaller degree, municipal water use. Figure 4-1 illustrates water consumption by the major water users in the subbasin.

Irrigation usually reduces monthly streamflows during the irrigation season from May through early September. Irrigation return flows may increase streamflows following the irrigation season from October to February. Increases and decreases of streamflow depend on site-specific factors such as the amount of water withdrawn, type of irrigation system, irrigation management, crop and soil types, drainage system layout, and soil characteristics. Less efficient irrigation systems, such as flood irrigation and water spreading, require relatively large amounts of water, much of which returns to the stream. In contrast, more efficient irrigation systems, such as sprinklers, require less water, and the amount returned to the stream also is less.

On the average, approximately 25 percent of the water diverted in this portion of the Missouri River basin is used by crops or noncrop plants, or lost to evaporation or percolation into deep aquifers (Soil Conservation Service 1978). The remaining 75 percent of the diverted water returns to the system as surface and groundwater return flows.

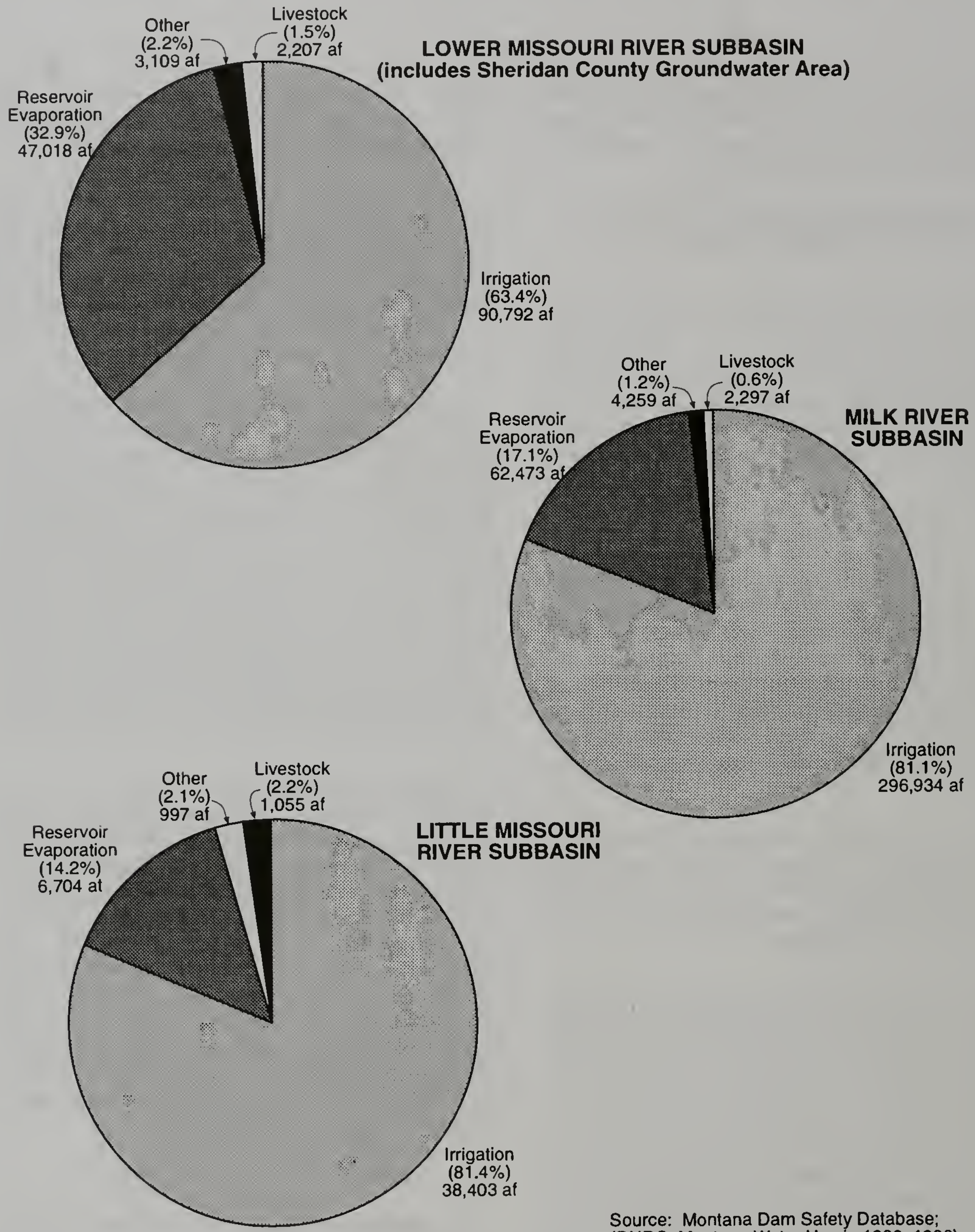
Municipalities alter streamflows in much the same way as irrigation except that water is used year-round. Demands increase during the summer because of lawn and garden watering. According to information in the municipal water reservation applications (Aquoneering 1991), approximately 15 percent of the water diverted is consumed by evaporation or other processes, and lost to the system. Water that is not consumed, such as return flows from irrigation of parks and lawns, and water that leaks from distribution pipes, may eventually return to a stream. Water that has been routed through the sewer system also will return to the stream or aquifer after treatment.

Reservoir operations also alter natural streamflow patterns. Most reservoirs are used to store high spring flows, and release water as needed during the months of naturally low flows. Maximum drawdown is usually achieved by the end of the winter, just before high spring flows begin. Reservoir evaporation also depletes water. Evaporation from Fort Peck Reservoir, for instance, is estimated to be 716,000 acre-feet per year (Corps 1991). Most small reservoirs are designed for a single purpose, such as irrigation or stock watering, and may run dry at the end of the demand season. In contrast, large reservoirs typically store water for more than one use and have numerous operational criteria.

#### LOWER MISSOURI RIVER BASIN

The flow distribution of the Missouri River below Fort Peck Reservoir is regulated by the dam. Fort Peck Reservoir is the uppermost of a system of seven

**Figure 4-1. Consumptive Water Use by subbasin**



Source: Montana Dam Safety Database;
(DNRC, Montana Water Use in 1980, 1986)

reservoirs regulated by the Corps on the Missouri River in Montana, North Dakota, South Dakota, and Nebraska. The release patterns at each reservoir depend on a number of variables including system storage, estimated inflows, instream requirements, navigation demands, and hydropower demands. Average monthly releases typically are largest from December through February (Figure 4-2) as Fort Peck is drawn down for spring runoff. Minimum releases of 3,000 cfs may occur during any month, but are most common during spring and fall.

The Fort Peck hydro powerplant also is used to satisfy power peaking demands. The maximum possible range for daily peaking operations is 12,000 cfs—between the minimum flow volume of 3,000 cfs and the maximum powerplant capacity of approximately 15,000 cfs. However, typical peaking patterns are considerably less than this. Figure 4-3 shows typical hydropower peaking (Corps 1993). For an average daily release of 11,400 cfs, flows would range from 7,200 cfs to 13,700 cfs. Peaking operations occasionally will result in larger than the "typical" fluctuations. Figure 4-4 illustrates large daily fluctuations during peaking operations over one week in 1985. River levels may vary daily up to 2.5 feet below the dam during typical peaking operations. These daily fluctuations decrease with distance downstream and are considerably smaller downstream at Wolf Point and practically nonexistent at the North Dakota border (Figure 4-5).

Water reservations were applied for on three principal tributaries to the lower Missouri River—the Redwater River, the Poplar River, and Big Muddy Creek. Each of these streams has a runoff peak in the spring, followed by lower, highly variable summertime flows. No-flow conditions also occur. Flow patterns on the Redwater River are relatively unaltered from the natural state. The Poplar River is the largest of the three tributaries. It has ceased to flow for at least 1 day during 9 out of 51 years for which complete data are available (USGS 1994). Natural streamflow patterns are altered by irrigation and by flows from Cookson Reservoir in Saskatchewan. Big Muddy Creek drains the northeastern corner of the state. Although most of the Muddy Creek drainage is relatively undeveloped, the lower reaches are highly regulated by diversions to Medicine Lake National Wildlife Refuge.

### MILK RIVER SUBBASIN

The Milk River drains over 22,000 square miles in Montana and Canada. For most of the twentieth century, however, the existing flow pattern has been predominantly controlled by water imports from the Saint Mary River basin, reservoir storage, and irrigation. Before that time, natural flows in the Milk River were typically erratic, and dominated by runoff from prairie snowpack and sporadic summer rainstorms. Nearly half of the average annual flow at Havre during the irrigation season is contributed by the Saint Mary Canal (Table 4-1) to supply water for some of the 140,000 acres of irrigated land in the Milk River drainage. Fresno and Nelson reservoirs also are used to regulate flows for irrigation. The combined storage of these two reservoirs is 208,286 acre-feet (BUREC 1981), substantially more than the average annual flow at Havre, if imports from the Saint Mary Canal are excluded.

**Table 4-1. Average annual flow in the Milk River subbasin**

| Station | Mean Annual Flow (acre feet) |
|---|---|
| Milk River at Havre[1] | 300,800 |
| Saint Mary Canal[2] | 140,457 |
| Milk River at Nashua[1] | 477,500 |

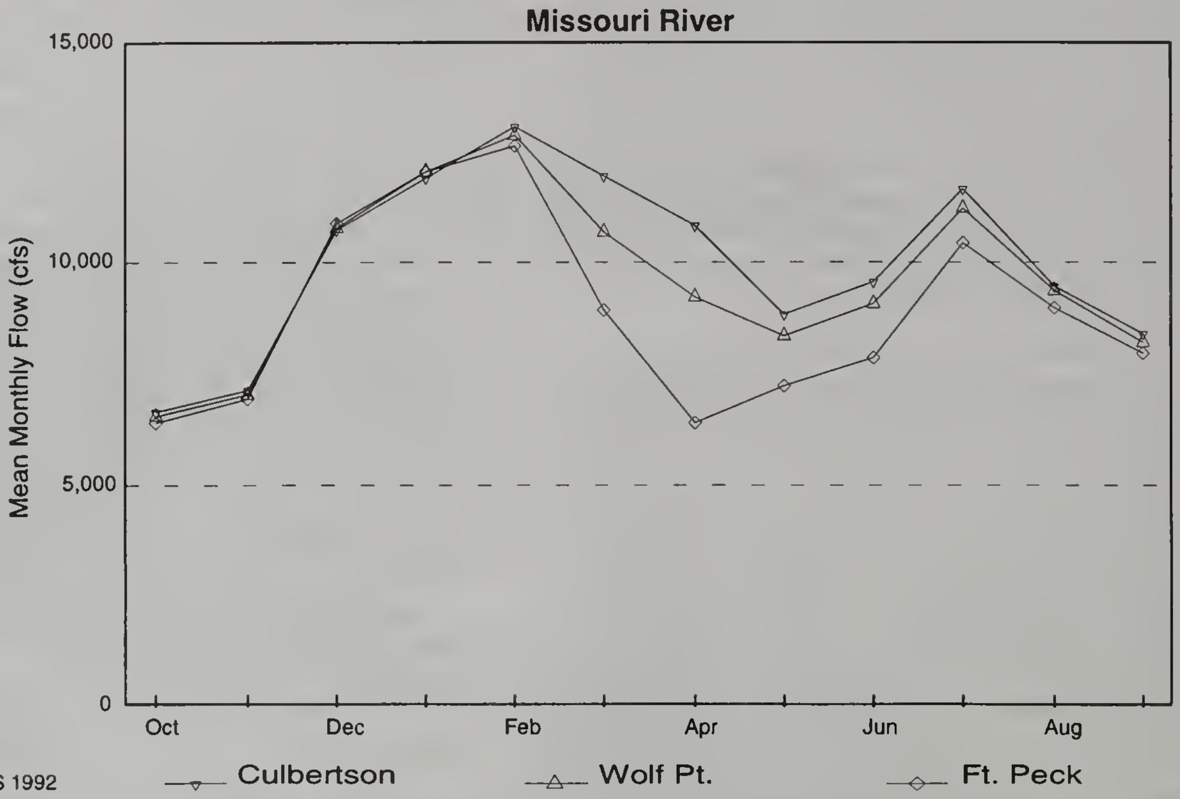
[1] (USGS 1993)
[2] (DNRC 1977)

The seasonal flow distribution in the Milk River changes with distance downstream from Havre. The Milk River at Havre is regulated by Fresno Reservoir. Flows are highest from April through September when releases are being made for irrigation (Figure 4-6). Flows seldom fall below 22 cfs due to minimum release criteria at Fresno Reservoir.

Between Havre and Saco, a substantial portion of the streamflow is diverted for irrigation and to fill Nelson Reservoir. No-flow conditions are not unusual during the irrigation season.

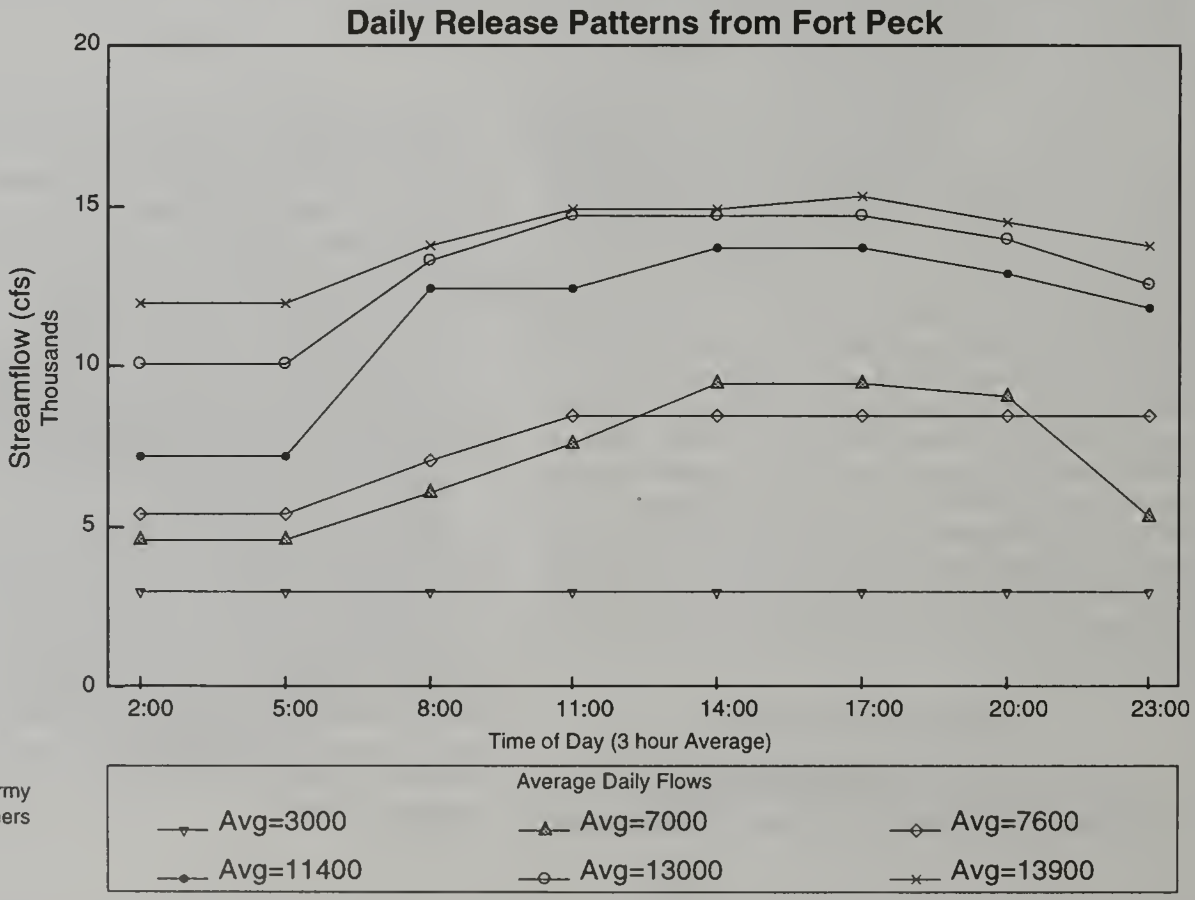
The lack of storage downstream from Saco allows flow patterns to reflect the vagaries of unregulated tributary inflow to a larger degree. The resulting seasonal flow distribution at Nashua is, therefore, decidedly peaked during the April runoff (Figure 4-6). Fall streamflow volumes are generally larger at Nashua than at upstream sites due to the larger area that is contributing groundwater baseflow. This baseflow includes return flows from the summer irrigation season.

**Figure 4-2. Average monthly flows for the Missouri River below Fort Peck Dam**



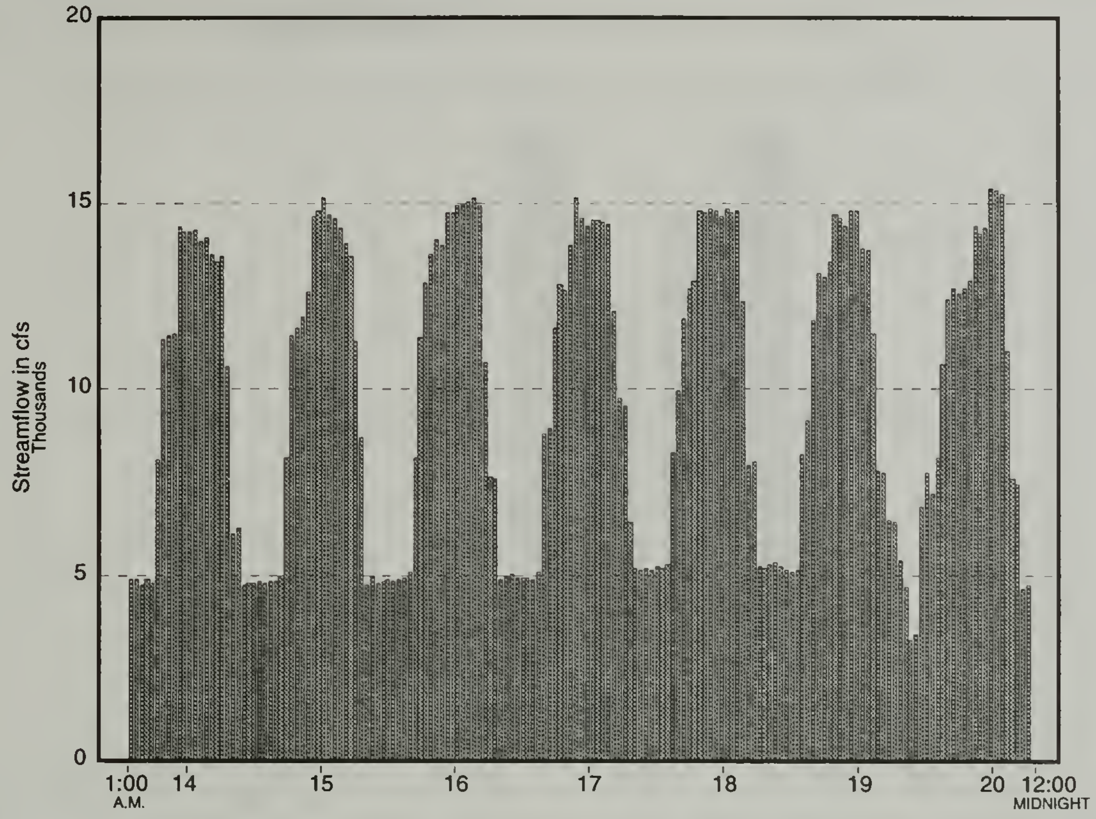
Source: USGS 1992

**Figure 4-3. Typical August daily Missouri River flow fluctuation that results from peaking operations at Ft. Peck Dam**



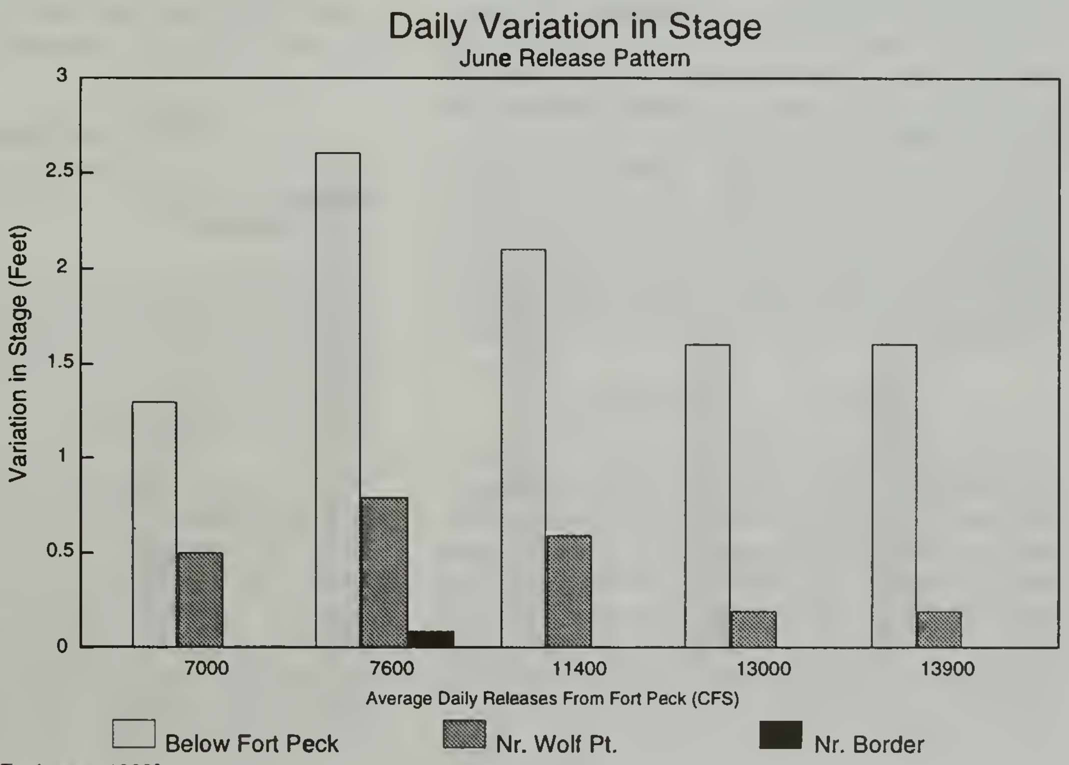
Source: U.S. Army Corps of Engineers 1993[a]

**Figure 4-4. Hourly releases from Fort Peck Reservoir for July 14-20, 1985 illustrating large variations in hourly flows**



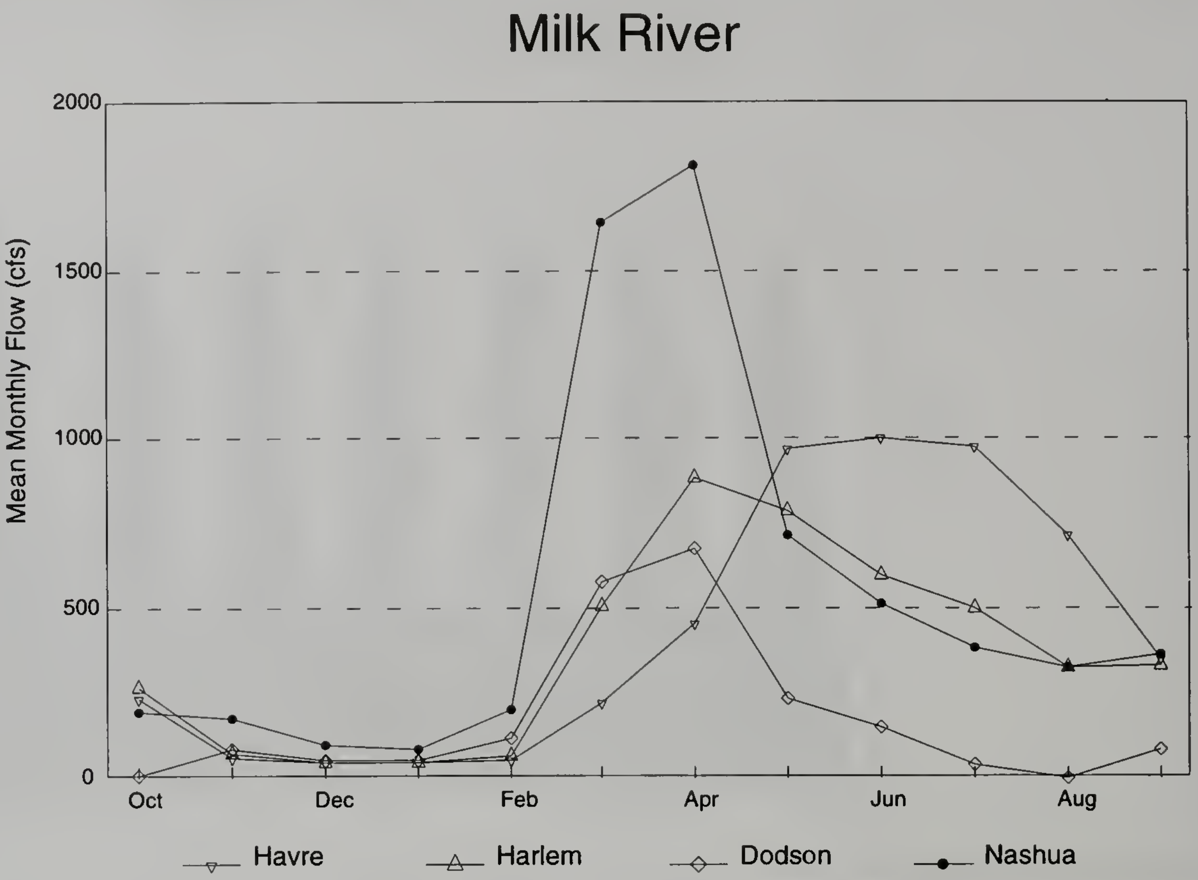
Source: U.S. Army Corp of Engineers, 1993[b]

**Figure 4-5. Daily fluctuation in Missouri River stage with a typical June release pattern**



Source: U.S. Army Corp of Engineers, 1993[a]

Figure 4-6. Average monthly flows for the Milk River



Water reservations have been requested for three tributaries of the Milk River—Battle Creek, Lost Coulee, and an unnamed tributary of Black Coulee. The flows on each of these streams peak in the early spring and taper off as the summer proceeds. Late summer flows may vary substantially due to summer rainstorms. No-flow conditions are common. Natural flow patterns in Battle Creek are modified by a number of irrigation diversions, primarily in Saskatchewan. Flows also can be diverted in either direction between Battle Creek and the Frenchman Creek basin through Cypress Lake in Saskatchewan.

### LITTLE MISSOURI RIVER SUBBASIN

Four streams in the Little Missouri River subbasin drain the eastern portions of Montana. These are Beaver Creek, Little Beaver Creek, Boxelder Creek, and the Little Missouri River. Natural flow in these streams is typically high during the spring runoff and lower throughout the rest of the year (Figure 4-7). Sporadic thunderstorms cause summer flows to be highly variable. It is not unusual for any of these streams to cease flowing at times. Their natural flow pattern is altered by the effects of extensive water-spreading irrigation in the spring.

# GROUNDWATER

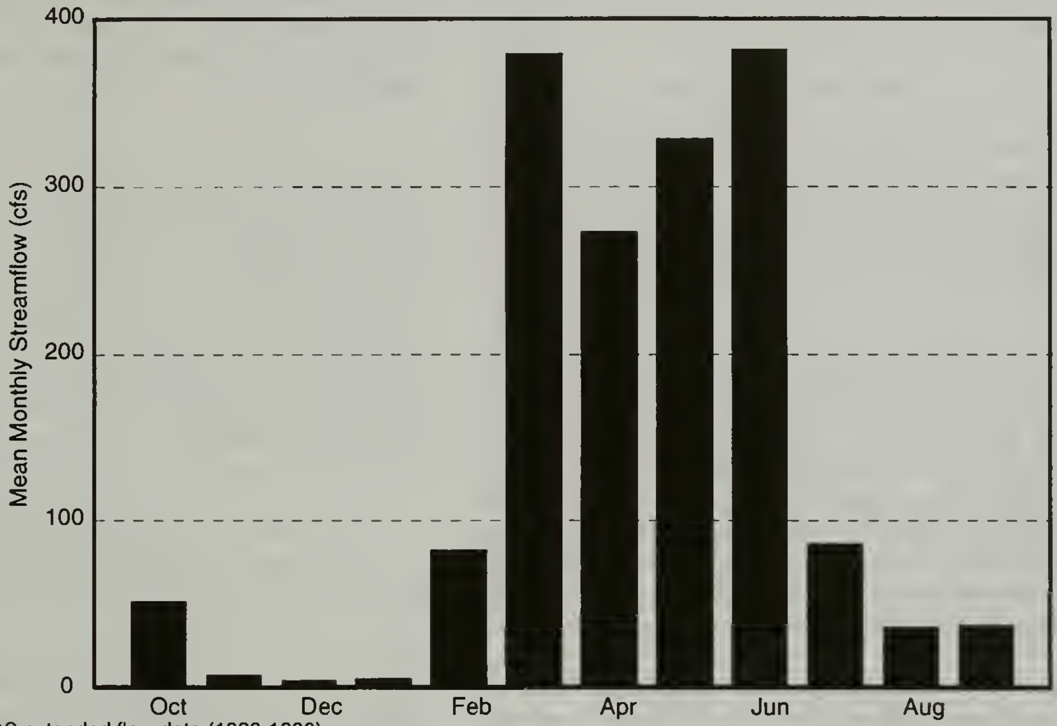
## INTRODUCTION TO GROUNDWATER IN THE BASIN

Aquifers in the lower Missouri River basin include both bedrock formations and deposits of gravel, glacial materials, and alluvium (Groff 1958; Bergantino 1986). The bedrock formations consist of generally flat-lying sedimentary rocks.

The uppermost bedrock formations in most of the lower Missouri River basin consist of sandstone, shale, silt, and coal. Table 4-2 lists the principal bedrock aquifers in each subbasin. Several older aquifers, such as the Madison Limestone, lie deeply buried throughout most of the study area. Because of their depth and often poor water quality, these aquifers are not usually used as sources of water.

Source: USGS 1994

**Figure 4-7. Average monthly flows for the Little Missouri River at Camp Crook, South Dakota**



Source: From the USGS extended flow data (1928-1986)

**Table 4-2. Principal bedrock aquifers in each subbasin**

| Subbasin | Aquifer |
|---|---|
| Milk River subbasin | Judith River Sandstone<br>Eagle Sandstone<br>Kootenai Formation |
| Lower Missouri River subbasin | Fort Union Formation<br>Hell Creek Sandstone<br>Fox Hills Sandstone |
| Little Missouri River subbasin | Fort Union Formation<br>Hell Creek Sandstone<br>Fox Hills Sandstone<br>Kootenai Formation |

The Flaxville Gravel is an unconsolidated to poorly consolidated preglacial sand and gravel deposit located at higher elevations on the plateaus north of the Milk River. This formation contains high quality water in quantities sufficient for irrigation in northern Blaine and Valley counties.

Glacial deposits blanket most of the lower Missouri River basin north of the Missouri River. These deposits generally are less than 100 feet thick and consist of glacial till and outwash. Glacial till is a mixture of poorly sorted material from clay to cobble size and is generally not a good aquifer. Glacial outwash is composed of sand and gravel deposited by glacial meltwater and typically contains large quantities of water.

Alluvium consists of gravel, sand, silt, and clay deposited by rivers. Alluvium up to 100 feet thick underlies the surface of flat valleys throughout the lower Missouri River basin. These deposits are an important water source in the region, with good yields of groundwater common at shallow depths. Many communities along the Milk and Missouri rivers use groundwater from alluvium for drinking water and other uses.

Groundwater occurs in both unconfined and confined aquifers. In an unconfined aquifer, the water table (top of the zone of saturation) can move up or down without encountering any barriers. In a well completed in an unconfined aquifer, the water level in the well rests at the same elevation as the water table in the aquifer. In a confined aquifer, groundwater is under pressure and is confined by some overlying, relatively impermeable strata such as clay. Water levels in wells completed in confined aquifers rise to some level above the bottom of the confining layer. This level is known as a potentiometric surface. In some cases, the pressure in a confined aquifer causes wells to flow at the surface.

## SHERIDAN COUNTY GROUNDWATER AREA

### GEOLOGIC SETTING

During the Ice Age, retreating glaciers left behind large channels filled with sand and gravel in southern and eastern Sheridan County. These coarse, permeable sediments are generally saturated and capable of yielding large quantities of water to wells.

The largest channel extends from the Big Muddy valley near Medicine Lake northeast to Westby and then east into North Dakota (see Map 4-1). This is known as the Westby-Dagmar channel. It is also called the Skjermo Lake aquifer in North Dakota and the Clear Lake aquifer in Montana. It is about 40 miles long and 2 to 3 miles wide in most areas. The total thickness of sand and gravel deposits ranges from less than 5 feet at the margins of the channel to over 200 feet in some areas near the center.

Smaller outwash channel tributaries to the Westby-Dagmar channel (shown in Map 4-1) are the Stady, Grenora, Sand, Coalridge, and Cottonwood Creek channels. They contain 20 to 120 feet of sand, gravel, and other glacial deposits. Glacial outwash also is found in modern drainage channels such as the Big Muddy Creek and Missouri River valleys.

The major aquifer system formed by the channel deposits has been studied in considerable detail by the Montana Bureau of Mines and Geology (MBMG) (Donovan 1988) and the USGS (Levings 1986).

Groundwater in the Westby-Dagmar channel generally moves from the North Dakota border southward to the Brush Lake/Dagmar vicinity, then southwest towards Medicine Lake. The aquifer is recharged largely by infiltration from precipitation and streamflow. Discharge occurs largely as evaporation and transpiration by plants.

The Westby-Dagmar channel is low-lying and flat relative to the surrounding landscape, and many lakes, ponds, and swamps lie within the channel. These lakes are connected in various degrees to groundwater in the underlying aquifer. Some lakes and ponds are basically perched atop nearly impermeable clay and are fed only by precipitation runoff. Other lakes have groundwater flowing into them, out of them, or both, and also capture precipitation runoff.

The principal lakes in the Westby-Dagmar channel were categorized by Donovan (1988) as open, closed, or restricted outflow types. Generally, closed or restricted outflow type lakes tend to have poor water quality because the concentration of minerals in the lake increases as water is removed by plants and evaporation.

The preglacial or ancestral Missouri River in northeastern Montana flowed northeastward from a point near Poplar through a wide valley that is now buried by glacial debris. This buried valley extends from near Poplar northeast beneath Medicine Lake and the Dagmar channel (see Map 4-1). River gravel deposited by the preglacial Missouri River is still in place as subsurface layers of terrace gravel 20 to 90 feet thick. This gravel is a productive aquifer in some areas and is known variously as the Wiota Gravel and the ancestral Missouri terrace gravel.

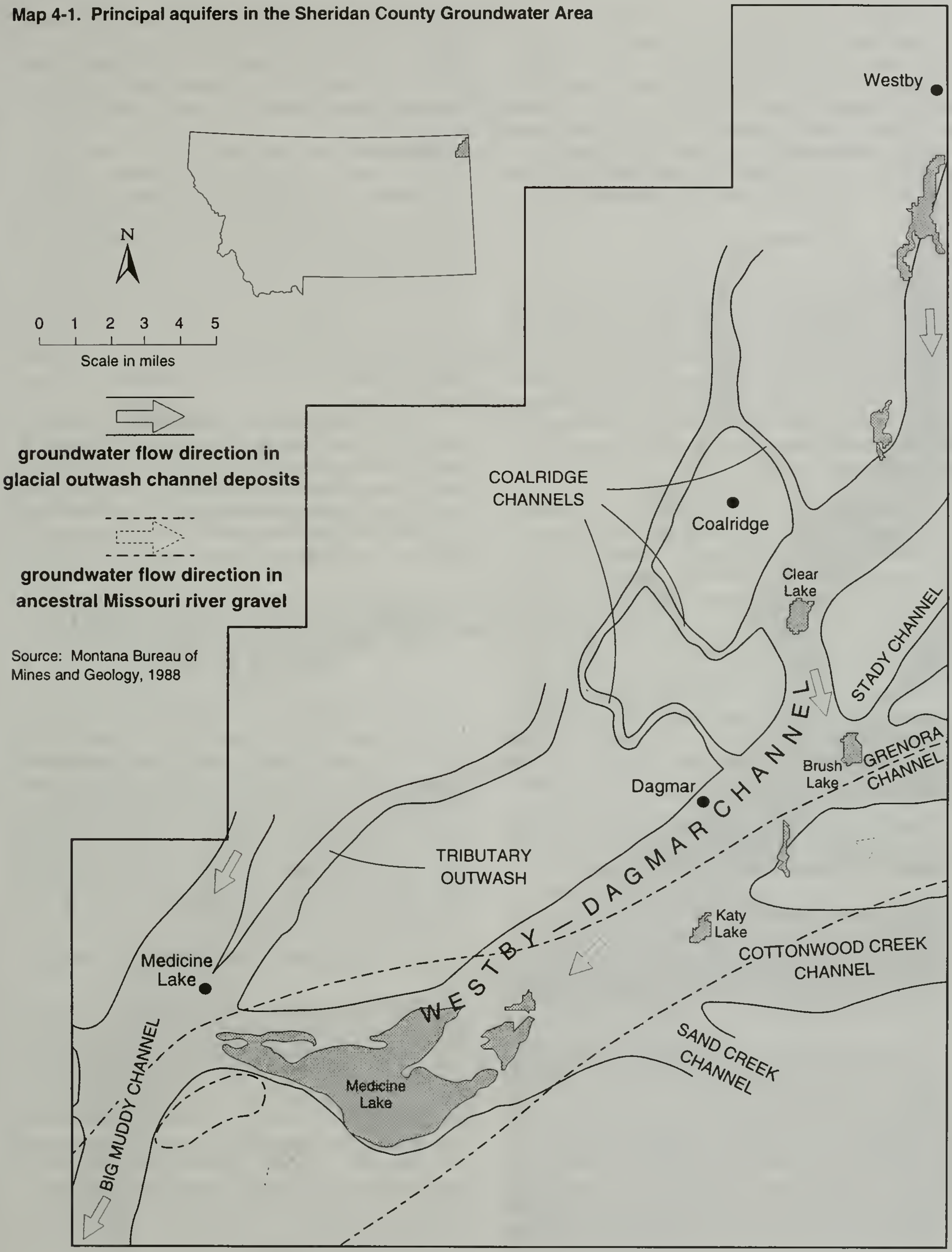
The glacial aquifers in Sheridan County form a complex aquifer system. The various aquifers are known to connect or not connect to one another in some locations, while it is unclear how they may be related in other locations. In a context of aquifer management, it is useful to use the term "aquifer system" to refer to all of the major outwash and terrace gravel aquifers in southeastern Sheridan County, shown in Map 4-1.

### WATER USE

MBMG calculated the volume of water pumped from the Westby-Dagmar channel for irrigation in 1984 to be 5,275 af. The annual average volume from 1983 to 1988 was estimated at 4,821 af (Donovan 1988). In 1988, the calculated usage was 6,025 af, the highest volume used up to that date. The total annual volume permitted by DNRC for high-yield irrigation wells in both the Westby-Dagmar channel and the ancestral Missouri terrace gravel east of Big Muddy Creek as of February 1993 was 8,126 af/yr. This area has 26 irrigation systems ranging from 123 to 250 acres. Wells that supply water for these irrigation systems are largely situated on the Westby-Dagmar channel although one or two are in the ancestral Missouri terrace gravel. Generally, permitted volumes are greater than the volumes actually used.

USFWS holds water rights for 19,570 af/yr of groundwater "tributary" to Medicine Lake. Since this lake is connected to the Westby-Dagmar channel, groundwater in the aquifer is important to USFWS operations.

**Map 4-1. Principal aquifers in the Sheridan County Groundwater Area**



Source: Montana Bureau of Mines and Geology, 1988

Medicine Lake, Homestead Lake, and other smaller lakes in the vicinity are managed by USFWS as components of the Medicine Lake National Wildlife Refuge. The lakes receive spring runoff from major tributaries and USFWS diverts spring runoff to the lakes from Big Muddy Creek if runoff is available. During the summer, water is released slowly from the lakes. The lakes are drawn down late in the year to make room for runoff the following spring.

### WATER LEVELS

Annual precipitation recorded at Medicine Lake Wildlife Refuge was less than normal during the years 1983 through 1990, with the exception of 1986. The annual precipitation for six of these years was in the range of 8 to 10 inches compared with an annual average of 13.4 inches for the period beginning in 1939. This drought undoubtedly has contributed to declines in lake water levels and groundwater levels in some aquifers.

Hydrographs in Figure 4-8 illustrate general groundwater level trends in the northern portion of the Westby-Dagmar channel outwash (top), the southern portion of the Westby-Dagmar outwash (middle), and the ancestral Missouri River Terrace gravels (bottom). Based on data from eight USGS observation wells, groundwater levels in the Westby-Dagmar channel north of Clear Lake declined about 6 to 9 inches a year between 1982 and 1990. Measurements since 1990 indicate groundwater levels in the northern portion of the Westby-Dagmar channel have generally remained at about 1990 levels, with little or no further decline through the fall of 1992.

Declines in groundwater levels measured in observation wells in the Westby-Dagmar channel south of Clear Lake and in ancestral Missouri River Terrace gravels were 2 feet or less between 1982-1992. It may be that the maintenance of water levels in the USFWS lakes by importing water from Big Muddy Creek tends to stabilize groundwater levels in the southern portion of the Westby-Dagmar channel outwash to some extent.

The portion of the Westby-Dagmar channel extending into North Dakota is known as the Skjermo Lake aquifer. The North Dakota State Water Commission (NDSWC) completed an interim report on this aquifer in 1983 and has prepared annual updates every year up to 1992. NDSWC has observed declining groundwater levels, especially toward the Montana border end of the aquifer where irrigation withdrawals are heaviest. NDSWC has issued few new permits to appropriate water from this aquifer since 1983. The 1987 NDSWC update on the Skjermo Lake aquifer noted that a water level decline of 4 feet in 5 years is not necessarily alarming in light of the low rainfall during the period 1983 to 1987.

Medicine Lake and other lakes managed by USFWS were several feet below optimum management levels in most years from 1980 to 1992. A decline in water quality was associated with declining water levels in these lakes (Reiten 1992). Specific conductance measurements, which provide a general sense of the total dissolved solids content in water, were determined at a number of sites in 1984 and again in 1990 (Reiten 1993). The specific conductance of lake water increased dramatically from 1984 to 1990, more than 100 percent in many cases.

Above normal annual precipitation in Sheridan County in 1991 and near normal precipitation in 1992 occurred largely as late spring and summer rain. This precipitation was largely soaked up by soil and did not produce much runoff. This benefitted crops but provided little relief to the low water in the Medicine Lake National Wildlife Refuge.

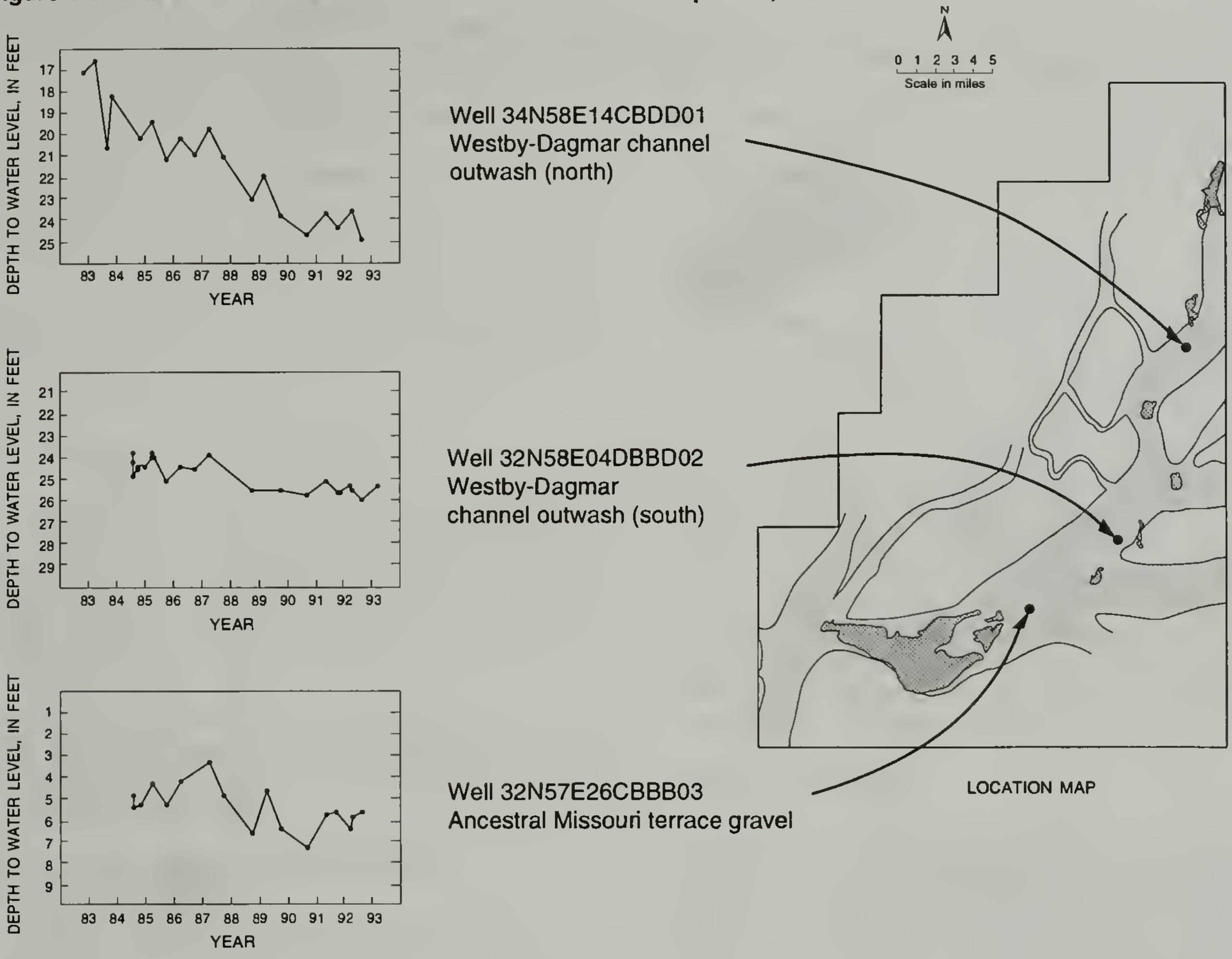
## LEGAL WATER AVAILABILITY IN THE LOWER MISSOURI RIVER BASIN

For the Board to grant a water reservation, it must find that the reservation will not adversely affect senior water rights. Although all applicants claim that water is physically available for their reservations, this water may already be appropriated under existing water claims, permits, or federal reserved water rights that have a priority date before July 1, 1985, for the Missouri and Milk rivers and their tributaries, or July 1, 1989, for the Little Missouri River and its tributaries.

### STATUS OF WATER RIGHT CLAIMS

Claims for existing state water rights in the lower Missouri River basin are summarized by use and subbasin in Appendix A. Montana water law defines a claim as a water right that was in existence before July 1, 1973, which was the effective date of the Montana Water Use Act. Claims will eventually be adjudicated for 85 adjudication subbasins covering all of Montana. Of these, 19 subbasins lie within the lower Missouri River basin below Fort Peck Dam.

**Figure 4-8. Water levels in selected wells in unconsolidated aquafers, 1982-1993**



Source: USGS undated

Map 4-2 indicates the status of the adjudication in those 19 subbasins. The courts have issued a final decision or "Final Decree" for only two of the subbasins—40P and 39H—on Map 4-2. Preliminary decrees have been issued in subbasins 39G and 40N. Temporary preliminary decrees have been issued in six other subbasins. A temporary preliminary decree is different from a preliminary decree in that the latter does not involve federally reserved water rights. DNRC is examining claims in basins 40F, 40J, 40M, and 40O. The remaining five subbasins have had little or no activity related to the adjudication, and most of these basins will not be examined by DNRC or acted upon by the Water Court before the reservation process is completed.

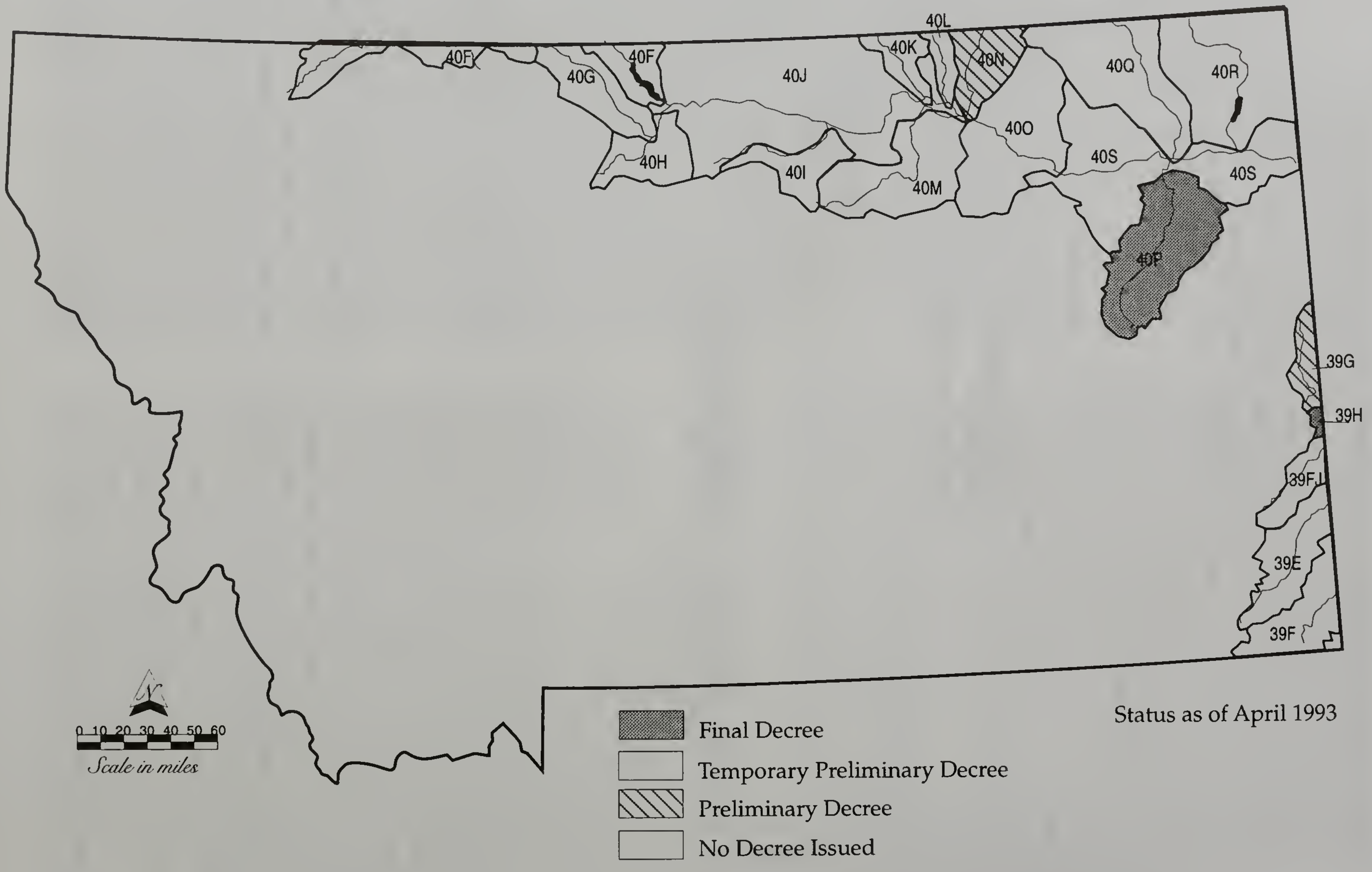
## STATUS OF WATER RIGHT PERMITS

Provisional water use permits are water rights issued by DNRC since July 1, 1973, as summarized in Appendix A. In this draft EIS, provisional water use permits have been sorted into two categories: before and after the reservation priority dates (July 1, 1985, for the Missouri and Milk River drainages, and July 1, 1989, for the Little Missouri River drainage).

### MILK RIVER SUBBASIN

Because of persistent water shortages, no new permits are being issued for direct diversions without storage from the Milk River from its eastern crossing of the Canadian border to Fresno Dam. It is closed from June 15 to September 30 from Fresno Dam to Vandalia Dam. Water development is intense in the Milk River subbasin, with irrigation districts such as the Fort Belknap, Alfalfa Valley, Zurich, Harlem, Paradise Valley, Malta, and Glasgow, and numerous private pumps placing heavy demands on the river. Even though water is imported into the Milk River from the Saint Mary River and despite numerous storage facilities, the largest being Fresno and Nelson reservoirs, water shortages are still acute.

Map 4-2. Status of Water Rights Adjudication in the Lower Missour Basin



DNRC prepared a study of water availability in the Milk River main stem (DNRC 1977). From the river's eastern crossing of the international boundary to Fresno Dam, DNRC found that water is available only in 2 years out of 10, and then only during spring runoff. In the stretch from Fresno Dam to Vandalia Dam, water is available for future appropriation in only 5 years out of 10 during the months of June through September, but the amount of water available during this period is small. Unexercised prior existing rights of Canada and the Fort Belknap Indian Reservation, if exercised, would further reduce the amount and frequency of unappropriated waters in the basin.

## INTERNATIONAL WATERS

The United States and Canada share the water of the Milk River and many of its tributaries, including Battle Creek, Rock Creek, Frenchman Creek, the Poplar River, and Big Muddy Creek. The Boundary Waters Treaty governs the allocation of Milk River water between the two countries.

The two countries have not formally settled how they will divide the flows of the Poplar River and Big Muddy Creek. They seek to equally divide the water in the Poplar River basin.

## BOUNDARY WATERS TREATY

The Boundary Waters Treaty of 1909 governs allocation of Milk River and Saint Mary River water between the United States and Canada. The treaty was amended in 1921 and 1931. The treaty treats the two river basins together because water is diverted from the Saint Mary River into the North Fork of the Milk River during the irrigation season. During the irrigation season, the United States' share of the Saint Mary River at the international boundary is 25 percent of the natural flow up to a total of 666 cfs, with flows above that quantity divided equally between the two countries. On the Milk River, the United States is entitled to 75 percent of the flow up to 666 cfs, with any flow above that divided equally between the two countries. Milk River tributaries that cross the international boundary are to be divided equally between the two countries.

## FORT PECK RESERVOIR

The U.S. Army Corps of Engineers has water right claims associated with the operations of Fort Peck Reservoir. Water rarely spills from Fort Peck Reservoir, and all water passing through the dam is used to generate electricity. Average daily outflows have exceeded the dam's generator capacity in only six months during the 24-year period between 1967 and 1990. The claimed maximum capacity of the dam power plant is about 16,000 cfs. A preliminary decree issued for the basin in the vicinity of Fort Peck Dam and Reservoir lists the Corps' right as 11,700,000 af/yr at a rate up to 20,000 cfs for power generation.

## FEDERAL RESERVED RIGHTS

The federal government and Indian tribes claim reserved water rights in the basin for consumptive and instream uses. Reserved water rights are usually decided either by a compact between the state and tribal or federal agencies, or through litigation. The state's Reserved Water Rights Compact Commission negotiates federal reserved water rights with Indian tribes and federal agencies for the state. When reserved water rights are litigated, the state's attorney general assumes responsibility for defending the state's interests. To date, the only reserved rights that have been determined on a state level in the Missouri River basin are those for the Fort Peck Indian Reservation and National Park Service.

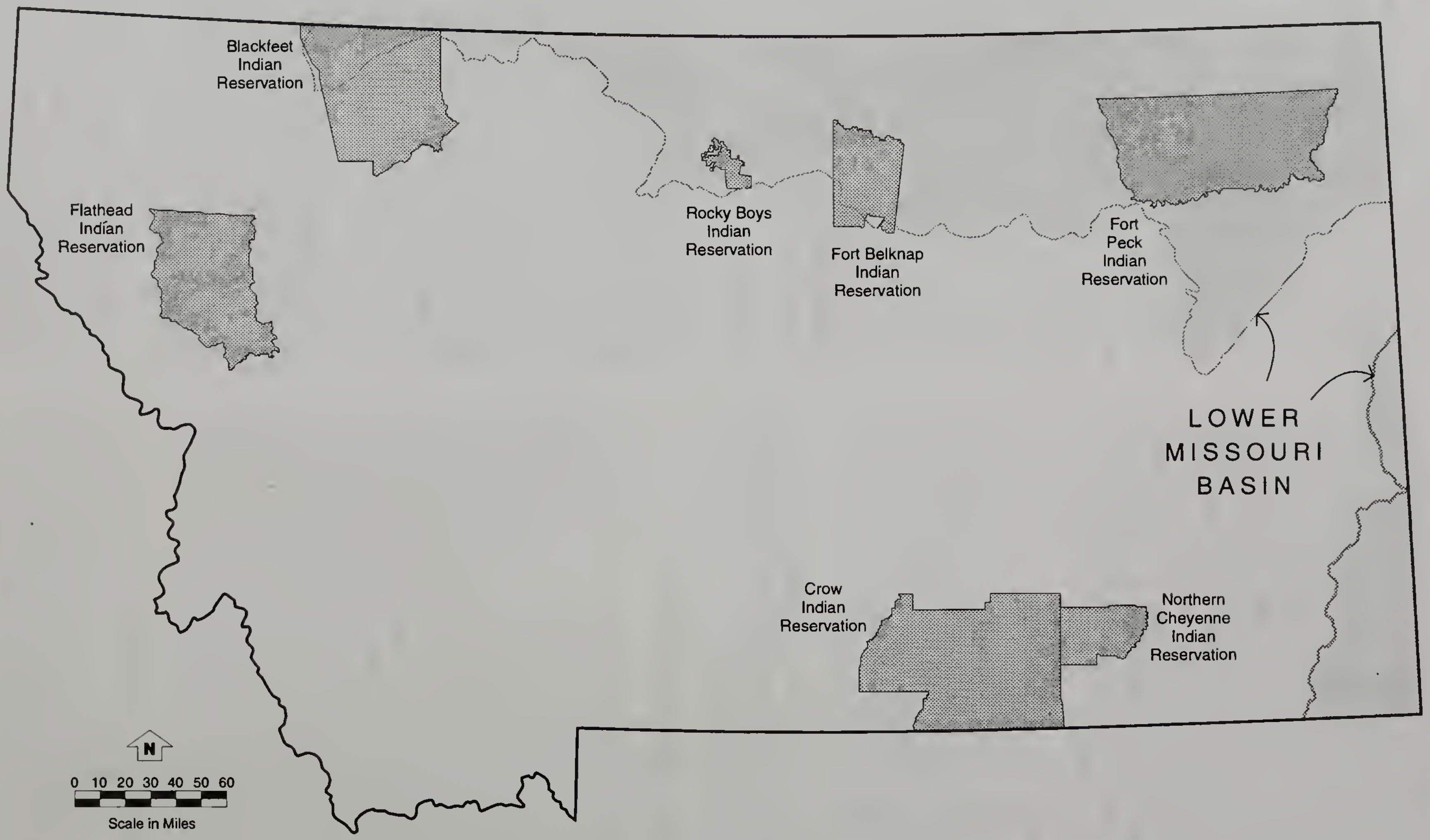
## INDIAN TRIBES

In 1908, the U.S. Supreme Court recognized reserved water rights for tribes on Indian reservations. Winters v. United States, 207 U.S. 564, 28 S. CT. 207, 52 L.Ed 340 (1908). Map 4-3 shows Montana Indian reservations where reserved rights have been claimed. Several tribes claim unspecified quantities of water in the basin for "aboriginal rights" with a priority dating from "time immemorial." Board of Control of Flathead Irr. D.V.,Et Al., United States, 832 F.2d 1127, 1131 (9th Cir. 1987). The following is a summary of claimed reserved water rights or proposed settlement of those rights by Indian tribes and federal agencies in the basin and their status.

**Blackfeet Reservation:** The Blackfeet Reservation is located in the northwestern portion of the basin and includes areas drained by the upper Milk River. The Blackfeet Tribe has claimed all waters arising upon, flowing through, bordering, or underlying the reservation. The priority date claimed for Blackfeet water rights is 1855.

The Blackfeet Tribe does not intend to negotiate its reserved water rights with the Reserved Water Rights Compact Commission. Therefore, the Blackfeet's rights will be determined in court. The State of Montana Attorney General's office will represent the state in the case. It is unlikely that the

Map 4-3. Locations of Montana Indian reservations


Blackfeet Indian Reservation
Flathead Indian Reservation
Rocky Boys Indian Reservation
Fort Belknap Indian Reservation
Fort Peck Indian Reservation
LOWER MISSOURI BASIN
Crow Indian Reservation
Northern Cheyenne Indian Reservation
N
0 10 20 30 40 50 60
Scale in Miles

reserved water rights of the Blackfeet Tribe will be settled by the courts before the Board acts on the proposed water reservations.

**Fort Belknap Reservation:** Most of the Fort Belknap Indian Reservation lies within the Milk River subbasin. An initial proposal by the Assiniboine and Gros Ventre tribes of the Fort Belknap Reservation sought the following reserved water rights:

| Source | Annual diversion (af/yr) |
|---|---|
| Regulated Milk River supply | 163,492 |
| On-reservation streamflow | 29,224 |
| On-reservation non-alluvial groundwater | 16,787 |
| **Total** | **209,503** |

However, the tribes are currently revising that proposal. The Reserved Water Rights Compact Commission and tribes of the Fort Belknap Reservation intend to negotiate a compact that defines the extent of the tribes' rights. Negotiations are not active, and it is unlikely that a compact will be completed before the water reservation applications are acted on by the Board. The Fort Belknap Reservation was created May 1, 1888, and the tribes claim this as their priority date.

**Rocky Boy's Reservation:** The Rocky Boy's Reservation is located in the Milk River subbasin and encompasses portions of the Big Sandy and Beaver Creek drainages. The initial proposal for settlement put on the table by the Chippewa Cree Tribe is for approximately 20,000 acre-feet of surface water per year from Big Sandy and Beaver creeks and their tributaries, and unlimited use of groundwater within the reservation. The Tribe believes it can supply its present and future water needs without significantly affecting non-Indian water users by increasing storage and by using groundwater. The Tribe proposes to enlarge Bonneau Reservoir on Box Elder Creek to about 7,000 af, to build a new multiple use storage reservoir on upper Big Sandy Creek with a capacity of about 4,000 af, a new reservoir on the upper reaches of Beaver Creek to store about 4,000 af, and several new municipal reservoirs with a collective storage capacity of 2,000 af. The Tribe also has proposed that the Big Sandy and Beaver creek basins should not be subject to call by senior mainstem Milk River water users. If the water supply of the Milk River is augmented by transfer of water from the Missouri River via the proposed Virgelle diversion, the Tribe believes it is entitled to an additional 32,500 af/yr for the irrigation of about 10,000 acres of land.

Negotiations are continuing between the Tribe and the Reserved Water Rights Compact Commission. However, it is unlikely that a compact will be negotiated before a decision is reached on the water reservation applications.

**Fort Peck Reservation:** The Fort Peck Reservation is located north of the Missouri River downstream from Fort Peck Dam. A compact was negotiated in 1985 between the Assinniboine and Sioux tribes of the Fort Peck Reservation and the Montana Reserved Water Rights Compact Commission. The compact was approved by the Montana Legislature, the tribes, and the United States. However, provisions of the compact allowing the tribes to market water must still be ratified by the U.S. Congress. The Fort Peck Reservation was formed on May 1, 1888, which is the priority date for these compacted rights.

Under the compact, the tribes are entitled to divert annually from the Missouri River, certain of its tributaries, and groundwater beneath the reservation the lesser of (1) 1,050,472 af of water, or (2) the quantity of water necessary to supply a consumptive use of 525,236 af. Of this, no more than 950,000 af per year or the quantity necessary to supply a consumptive use of 475,000 af may be diverted annually from surface water sources, primarily the Missouri River. The compact does not allow the tribes to divert water from the Milk River main stem. Maximum allowed rates of diversion from the Missouri River are as follows:

| | | | | | |
|---|---|---|---|---|---|
| Jan. | - | 650 cfs | July | - | 3,497 cfs |
| Feb. | - | 720 cfs | Aug. | - | 2,928 cfs |
| Mar. | - | 650 cfs | Sept. | - | 1,765 cfs |
| Apr. | - | 840 cfs | Oct. | - | 813 cfs |
| May | - | 1,708 cfs | Nov. | - | 672 cfs |
| June | - | 2,437 cfs | Dec. | - | 650 cfs |

The diversion schedule in the compact was developed with the cooperation of the Corps and reflects the Corps' operation of the Missouri River adjacent to the reservation. Under the terms of the compact, diverted water can be used within or outside of the reservation.

The compact allowed the tribes to establish reserved instream flows on streams flowing through the reservation (Table 4-3). The instream flows are part of the tribal water right and have a May 1, 1888, priority date. However, these tribal instream flow rights are subordinate to upstream irrigation rights that existed prior to the 1985 compact. Instream flows are counted by the tribes as a consumptive use of surface water.

The Fort Peck Reservation compact will be incorporated into all applicable water decrees by the Water Court during the adjudication process.

**Turtle Mountain Reservation:** The Turtle Mountain Indian Reservation is located in North Dakota. Pursuant to an agreement between the tribes of the reservation and the federal government in 1892 and the subsequent ratification of the agreement by Congress in 1904, parcels of land scattered throughout the Dakotas and Montana are held in trust for individual Turtle Mountain tribal members. No negotiations are currently under way regarding reserved rights for these parcels.

## Federal Agencies

**U.S. Forest Service:** Portions of the Custer National Forest are located within the Little Missouri River subbasin. The U.S. Forest Service claims small consumptive use rights and instream water rights for watershed protection on streams flowing through land it administers. A memorandum of understanding has been entered into between the U.S. Forest Service and the Reserved Water Rights Compact Commission to set up a process for resolving Forest Service rights.

**National Park Service:** A few small headwater tributaries to the South Fork of the Milk River originate in Glacier National Park. The Reserved Water Rights Compact Commission and the National Park Service recently signed a compact that resolves federal reserved water rights for Glacier and Yellowstone parks. For the small Milk River tributaries, the compact grants the National Park Service 0.02 af/yr for consumptive use by back country hikers within the park, and the remaining flow of these streams for instream flow to the Glacier Park boundary.

**U.S. Fish and Wildlife Service:** The U.S. Fish and Wildlife Service (USFWS) claims federal reserved rights for the Black Coulee and Lake Bowdoin national wildlife refuges. There are no active negotiations between the USFWS and the Reserved Water Rights Compact Commission to resolve these claims.

## WATER STORAGE

Montana has an estimated 11,000 reservoirs ranging in size from small stockwater ponds to large multipurpose reservoirs impounding millions of acre-feet. Together these reservoirs have the capacity to store approximately 33 million acre-feet of water. Roughly half of this storage capacity is in Fort Peck Reservoir. Montana's eight largest reservoirs account for 91 percent of the state's total storage capacity. None of these large reservoirs are located in the lower Missouri River basin.

Most of the 9,270 storage projects in the Missouri River basin are upstream from Fort Peck Dam. Only 770 storage projects covering 46,461 surface acres have been built in the Missouri River basin downstream from Fort Peck (including the Milk River drainage) and 50 storage projects covering 520 acres in the Little Missouri River subbasin. Projects that store more than 5,000 acre-feet of water are listed in Table 4-4.

**Table 4-3. Monthly instream flows reserved by compact for streams on the Fort Peck Indian Reservation**

| | Monthly Flow (cfs) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | af/yr |
| Poplar River | 20.4 | 23.0 | 12.8 | 4.8 | 7.9 | 179.0 | 241.0 | 56.3 | 50.0 | 25.7 | 13.5 | 10.0 | 38,933 |
| M.F. Poplar River | 13.9 | 17.5 | 8.4 | 1.8 | 3.6 | 126.8 | 181.1 | 59.4 | 53.9 | 15.9 | 8.8 | 5.8 | 30,011 |
| W.F. Poplar River | 5.0 | 4.7 | 3.5 | 2.7 | 3.7 | 39.3 | 41.9 | 17.0 | 14.6 | 7.9 | 3.7 | 3.5 | 8,917 |
| Wolf Creek | 0.2 | 0.4 | 0.1 | 0.1 | 0.9 | 5.9 | 14.6 | 4.0 | 2.8 | 1.3 | 0.1 | 0.1 | 1,835 |
| L. Porcupine Creek | 0.7 | 0.7 | 0.6 | 0.5 | 0.6 | 10.5 | 13.4 | 3.5 | 2.6 | 1.1 | 0.4 | 0.5 | 2,118 |
| Tule Creek | 0.4 | 0.4 | 0.3 | 0.3 | 0.4 | 6.7 | 8.3 | 1.8 | 1.2 | 0.5 | 0.2 | 0.2 | 1,246 |
| Smoke Creek | 1.5 | 1.5 | 1.1 | 0.9 | 1.3 | 16.9 | 12.7 | 4.7 | 3.9 | 2.0 | 0.9 | 0.9 | 2,926 |
| Lake Creek | 0.4 | 0.4 | 0.3 | 0.3 | 0.4 | 6.5 | 3.3 | 1.1 | 0.9 | 0.4 | 0.2 | 0.2 | 870 |
| Big Muddy Creek | 3.9 | 1.0 | 0.2 | 0.1 | 0.3 | 3.5 | 50.4 | 22.2 | 15.1 | 12.8 | 2.9 | 2.1 | 6,902 |
| N.E. Wolf Creek | 0.4 | 0.4 | 0.3 | 0.2 | 0.3 | 4.2 | 3.2 | 1.2 | 1.0 | 0.5 | 0.9 | 0.2 | 773 |
| Porcupine Creek | 0.1 | 0.1 | 0.2 | 0.1 | 0.5 | 46.5 | 31.1 | 6.9 | 6.1 | 2.0 | 0.1 | 0.1 | 5,690 |
| Cottonwood Creek | 0.7 | 0.7 | 0.6 | 0.5 | 0.7 | 10.3 | 6.2 | 2.2 | 1.8 | 0.9 | 0.4 | 0.4 | 1,539 |
| Box Elder Creek | 0.4 | 0.4 | 0.3 | 0.3 | 0.4 | 5.7 | 5.7 | 1.2 | 1.0 | 0.5 | 0.2 | 0.2 | 973 |
| Chelsea Creek | 0.4 | 0.4 | 0.3 | 0.3 | 0.4 | 6.1 | 3.0 | 1.0 | 0.8 | 0.4 | 0.2 | 0.2 | 806 |

SOURCE: Fort Peck Tribal Executive Board 1990

Table 4-4. Lower Missouri basin storage reservoirs with a capacity of more than 5,000 acre-feet

| Name | Subbasin | Stream | Max. Storage (af) | Normal Storage (af) | Surface Area (acres) | Purpose | Owner |
|---|---|---|---|---|---|---|---|
| North Chinook Reservoir | Milk | Lodge Creek | 7,500 | 7,000 | 795 | I | North Chinook Irrigation Company |
| Dry Fork Reservoir | Milk | Dry Fork Creek | 6,229 | 6,229 | 406 | I,S,F | Aetna Insurance Company |
| Weigland Reservoir | Milk | Loan tree Coulee | 5,600 | 5,600 | 610 | S,F | Fort Belknap Reservation |
| Beaver Creek Reservoir | Milk | Beaver Creek | 8,700 | 6,270 | 185 | I | Hill County |
| Bullhook Dam | Milk | Bullhook Creek | 10,280 | 5,150 | 155 | FC | Havre |
| Fresno Reservoir | Milk | Milk River | 245,000 | 129,000 | 5,660 | I | BUREC |
| Frenchman Dam | Milk | Frenchman Creek | 21,000 | 7,010 | 800 | I | DNRC |
| Nelson Reservoir | Milk | Milk River | 79,200 | 79,200 | 9,000 | I | BUREC |
| Medicine Structure | Lower Missouri | Big Muddy Creek | 13,322 | 10,000 | 2,780 | FW | U.S. Fish and Wildlife Service |
| Medicine Lake Refuge #4 | Sheridan County | Lake Creek | 73,777 | 73,777 | 13,170 | FW | U.S. Fish and Wildlife Service |
| Medicine Lake Refuge #6 | Sheridan County | Big Muddy Creek | 13,322 | 13,322 | 2,080 | FW | U.S. Fish and Wildlife Service |

I-Irrigation, FC-Flood Control, F-Fire, S-Stock, FW-Fish and Wildlife

Source: DNRC dam safety data base

Storage projects provide many different benefits to basin users. They can regulate streamflows for flood control; store water for irrigation, municipal, industrial, and stockwater use; provide opportunities for flat water recreation; improve fisheries; and supply water for hydropower generation. Storage facilities also can have adverse impacts on recreation and aquatic and riparian habitat associated with free-flowing rivers, and can alter aesthetic views.

Between 1930 and 1970 there were few constraints on building water storage projects. Today, new storage projects are difficult to build because of poor economic conditions, environmental constraints, the lack of good building sites, the need to rehabilitate existing storage facilities, and the scarcity of state and federal funds.

Because of the importance of new storage to agriculture and other users, the issue of water storage was taken through the state water planning process in 1988-90. Three primary components were addressed: policy, financing, and regulation. The final plan section recommended legislation that was passed in April 1991. The legislation clarified water storage policy, defined the role of storage in solving water problems, and established guidelines for setting priorities among new storage and rehabilitation storage projects. A special water storage account was created with revenues to be issued in line with the following priorities: (1) rehabilitation of high hazard and unsafe dams; (2) enlargement and rehabilitation of other existing water storage projects; and (3) construction of new storage projects.

## REVIEW OF MISSOURI RIVER MAIN-STEM OPERATIONS

The Corps operates Fort Peck Dam and its other Missouri main-stem dams through an administrative framework called the Master Manual. This Manual was initially prepared in 1960 and is based on the Flood Control Act of 1944. It was last reviewed and updated in 1978.

Currently, the Corps operates the Missouri River system to prevent flood damage, to generate hydroelectric power, and to supply water for irrigation in the upper basin states. In the lower basin, the Corps emphasizes water requirements for meeting municipal and industrial needs, controlling water quality degradation, and supplying water for an 8-month navigation season. The largest water demand in the basin and from the six main-stem reservoirs is for barge traffic downstream from Sioux City, Iowa. Recreation and fish and wildlife are considered secondary purposes with only residual quantities of water provided to them.

Since the 1970s, the social, economic, and environmental circumstances in the Missouri Basin states have changed, and the current Master Manual does not reflect these changed values. Therefore, the governors of the Missouri Basin states requested the Corps to review and update the Manual. The Corps, with input from basin states and Indian tribes, began the Master Manual review in 1989. The process began with an analysis in 1990 through 1992 of 307 alternatives and their impacts and selection of seven alternatives for detailed evaluation in the spring of 1993. The draft EIS on the seven alternatives is scheduled for completion sometime in 1994.

As a part of the Master Manual review, the Corps is attempting to determine the economic and environmental impacts of changing river operations on the basin states and to find options for increasing the benefits to all users of the river system. At the same time, the Corps plans to consider options for mitigating environmental impacts and preserving threatened and endangered species.

Montana has a keen interest in the Master Manual review because the drought of the 1980s required the Corps to significantly draw down Fort Peck Reservoir to maintain the downstream navigation season, to the detriment of recreation and fish and wildlife in Montana. Montana would like to see recreation and fish and wildlife considered primary users of water in the Missouri River system. Montana contends that higher water levels in the mainstem reservoirs would increase hydroelectric generation and recreation opportunities throughout the basin. Timed releases from these reservoirs in the fall and winter could benefit navigation on the Mississippi River. Besides these benefits, less flow for navigation would mean more water for lower basin industries and municipalities.

## WATER QUALITY

### BASINWIDE OVERVIEW OF WATER QUALITY

Water quality in the lower Missouri River basin varies in relation to climate, runoff, and geology. Climate is characterized by cold dry winters, cool moist springs and warm summers. Average annual precipitation ranges from 11 to 14 inches with over 75 percent of the precipitation occurring from April through September. Much of the area is underlain by claystone, shale and sandstones of marine origin. Soils developed from these materials provide an abundant source of leachable salts and fine sediments.

Water quality at any given location on a river varies annually and with the seasons. Spring and summer runoff will dilute the base flow concentrations of many chemical constituents such as dissolved-solids and major ions. However, some physical water quality parameters such as turbidity and suspended-sediment concentration follow a reverse pattern and are highest during peak flows when the stream's erosive power is greatest. Year-to year variability also is pronounced. Low flows during the recent drought probably increased dissolved solids concentrations. A listing of lower Missouri River basin streams and their water quality classification is found in Appendix E.

Land and water use also can affect water quality. Farming practices, consumptive use of water, and municipal and industrial waste discharges can degrade water quality. Nonpoint sources contribute about 90 percent of the water pollution in the lower Missouri River basin. Common problems include elevated temperature and increases in suspended sediment, turbidity, salinity, and nutrients. Diversion and consumptive use of surface water and groundwater may affect how frequently intermittent streams go dry and how long they stay dry. Reduction in surface flows may increase water temperatures and reduce dissolved oxygen. In several of the subbasins, the suitability of water for irrigation is limited by salinity, sodium concentration, and toxicity caused by boron in the water.

Most streams in the lower Missouri River basin are classified B-3 or C-3 (see Table 2-1). Exceptions include some streams classified B-1 in the headwaters of the Milk River in Glacier County and several tributaries to the Milk River arising from the Bearpaw and Little Rocky mountains.

## PARAMETERS OF INTEREST

### CHEMICAL WATER QUALITY

**Total dissolved solids (TDS)** are the sum of all chemical constituents dissolved in water and an overall measure of its salinity. Although rain and snow are generally low in TDS, water from precipitation will dissolve and leach salts, nutrients, and trace-elements as it moves through the drainage. Salinity is generally lowest in perennial rivers fed mainly by snowmelt runoff. The major chemical constituents in surface water in the lower Missouri area are calcium, magnesium, sodium, bicarbonate, sulfate and chloride. Groundwater has variable TDS concentrations but typically is much more saline than surface water due to its long exposure to leachable salts in aquifers. At saline seep locations—an extreme example—TDS concentrations in groundwater range from 15,000 to 55,000 ppm. The salinity of water as indicated by TDS is an important indicator of the suitability of water for a variety of agricultural, industrial, and domestic uses. Specific conductance, the ability of water to transmit electricity, is closely correlated with TDS and is measured more frequently than TDS because such measurement is easy and inexpensive.

Guidelines for evaluating the suitability of water for irrigation were established by the United Nations Food and Agriculture Organization (FAO) in 1985. The salt tolerance of forage and crops depends on chemical and physical characteristics of soils and the relative proportions of specific ions such as sodium, magnesium, calcium, and boron. In general, TDS levels above 1,000 ppm limit the suitability of water for irrigation. As salt levels increase, crop and forage yields decline, and special management is required to maintain yield and soil tilth.

Water with TDS concentrations exceeding 500 ppm is unfit for human consumption. Livestock is less sensitive to saline water than humans and wildlife, but will generally not drink water if TDS concentrations exceed 2,000 ppm (cattle can adapt to saltier water if raised on it). Sensitivity of aquatic organisms to salts is difficult to generalize because of wide variability among organisms.

**Sodium Adsorption Ratio (SAR).** Excessive dissolved sodium concentrations in irrigation water may destroy soil structure and reduce permeability of the soil. In extreme situations the upper portion of the soil profile may become sealed, preventing infiltration of water (FAO 1985). Sodium Adsorption Ratio is a measure of the relative sodium hazard of irrigation water and this measure compares the availability of sodium relative to calcium and magnesium in water. The severity of permeability and infiltration problems caused by elevated levels of sodium in irrigation water also depends upon the type and amount of clay minerals in the soil, soil drainage and the salinity of applied water. Fine-textured soil that is poorly drained and contains expansive clay is at greatest risk when irrigated with high sodium water. Sandy soil will tolerate higher sodium levels. Up to a point, most soils will tolerate higher levels of sodium if the water has a high salt content (Bauder et al. 1990).

A portion of the surface water and groundwater in the study area has high bicarbonate concentrations which contribute to the sodium hazard. The presence of bicarbonate increases the relative availability of sodium and an adjusted SAR must be calculated and used to evaluate the sodium hazard under such conditions (FAO 1985).

**Trace-elements (arsenic, boron, and selenium).** Trace-elements are minerals that occur in very small amounts in soil, rocks and water. Several trace-elements are essential in minute amounts for normal growth of plants and animals. However, these same elements are very toxic to humans at concentrations slightly above the recommended minimums.

**Arsenic:** Arsenic is a toxic semi-metal with chronic, acute and carcinogenic health effects. Most arsenic in the Missouri River originates from geothermal springs in the upper Madison drainage of Yellowstone National Park. Near West Yellowstone, concentrations in the Madison are typically 200 to 300 ppm. Dilution by tributaries and sedimentation in Hebgen, Canyon Ferry, and Fort Peck reservoirs reduces arsenic concentrations to a range of about 2-14 ppb in the lower Missouri River (Figure 4-9).

In the Missouri Basin above Canyon Ferry, arsenic concentrations frequently approach or exceed the federal drinking water standard of 50 ppm. Although arsenic concentrations are lower in the Missouri River below Fort Peck Dam, they remain a concern. In 1990, DHES adopted an instream (ambient) standard that is based on EPA's one cancer case-per-million risk level for carcinogens. This standard will not allow any activities that increase arsenic in surface water that already has an arsenic concentration exceeding 20 parts per trillion. Arsenic concentrations in streamflow of the main-stem Milk and Missouri rivers exceed this level at all points.
Many of the municipalities in the lower Missouri River basin obtain water from groundwater sources relatively unaffected by arsenic. However, Glasgow and Culbertson obtain their municipal water from the Missouri River.

**Boron:** Boron is an essential trace-element, and most plants require small quantities for proper growth. Citrus fruits, wheat, barley, and many vegetables are very sensitive to boron concentrations in excess of about 2 ppm (FAO 1985). Sorghum, alfalfa, and sugar beets are relatively tolerant and boron concentrations less than about 4-6 ppm will not cause crop damage in most situations.

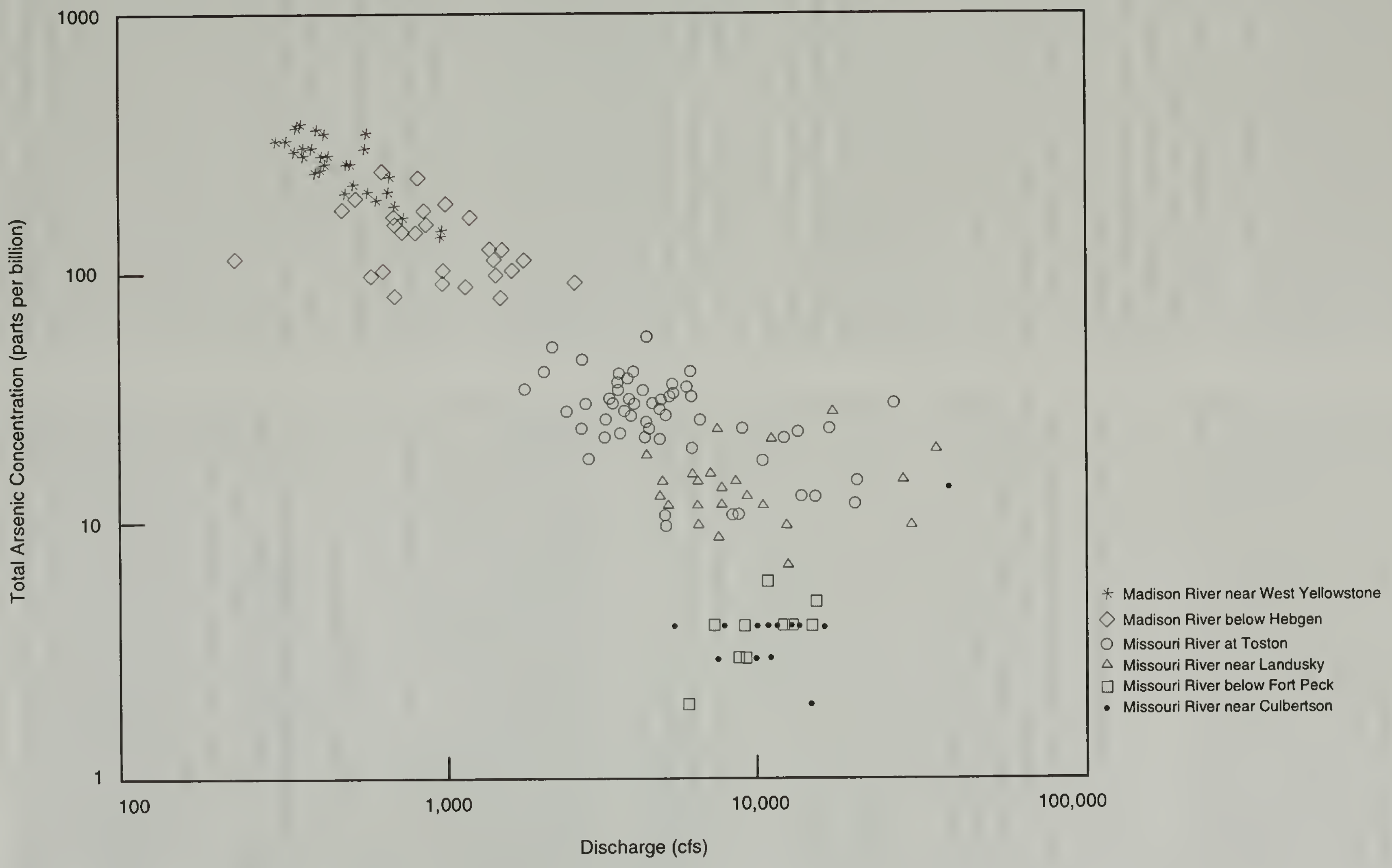
**Selenium:** Throughout much of geologic history, volcanic activity has been the main source of selenium in rock and soil materials. Weathering of Cretaceous shale deposits is the major source of selenium in the environment at present. Selenium is a relatively uncommon element essential to humans in very small concentrations. It is toxic to plants in concentrations as low as ppm. EPA has established ambient water quality criteria for freshwater aquatic life ranging from 20 ppm (short-term exposure) to 5 ppm (long-term exposure).

Waterfowl deaths, deformities and reproductive failures at Kesterson Reservoir in California established the link between irrigation drain water and elevated selenium levels. Concern over the potential for selenium mobilization at other areas led to the establishment of the National Irrigation Water Quality Program. Detailed examination of selenium in bottom sediments, drainage water, and wildlife tissue at 20 of 31 selected areas across the United States indicates that about 12 percent of the areas have elevated selenium levels. Recent evaluation of the Bowdoin National Wildlife Refuge and adjacent areas of the Milk River subbasin shows surface water has selenium concentrations less than 1 ppm (Engberg and Sylvester 1993; Lambing et al. 1988).

**Nutrients.** Phosphorous (P) and nitrogen (N) are the primary nutrients required for plant growth. Deficient or excessive amounts of either can cause plant growth and water pollution problems. Elevated levels of phosphorous and nitrogen can degrade water quality and cause excessive algae growth. Occurrence of phosphorous and nitrogen in water is affected by complex natural chemical and biological cycles. Flood irrigation of fertilized fields typically flushes a portion of these nutrients into streams and groundwater. Proper irrigation scheduling and efficient application of water can minimize nutrient leaching and input to surface water and groundwater.

**Nitrogen:** Nitrogen compounds are found everywhere in nature and are carried as soluble ni-

Figure 4-9. Relationship between arsenic concentrations and streamflows in the Missouri River



trate to groundwater. Notable sources of concentrated nitrates are commercial fertilizers, feedlots, mining operations where nitrogen blasting compounds are used, sewage effluent, the atmosphere, chemical spills, and agricultural runoff. The public drinking water standard for nitrogen is 10 ppm (as N). Nitrate-nitrogen has been found in saline seep areas in Richland County in concentrations over 500 ppm (Harlow 1974).

Sensitive crops (fruit, sugar beets) may be affected by nitrogen concentrations above 5 ppm; most other crops are affected above about 30 ppm. Excess nitrogen over-stimulates growth, delays maturity, and can accumulate in forage presenting a hazard to livestock and wildlife. Concentrations of nitrogen less than 5 ppm may stimulate nuisance growth of algae and aquatic plants in streams, canals, and pipelines.

**Phosphorous:** Major sources of phosphorus in the lower Missouri River basin are sediments, domestic sewage (including household detergents), processing wastes, and agricultural runoff, including fertilizer residues and animal wastes. Phosphate, the form most commonly found in natural-water systems, typically occurs in concentrations of a few tenths of a ppm Total phosphorus allowed by DHES standards is 0.10 ppm.

Phosphorus is essential for plant growth. Excessive amounts may cause algal blooms leading to a variety of other water quality problems including reduced dissolved oxygen and accelerated eutrophication weed growth in ponded water. Phosphorous is thought to limit the rate of eutrophication in many lakes and reservoirs because it usually is in shorter supply than nitrogen.

## PHYSICAL WATER QUALITY

**Total suspended solids (TSS)** is a measure of all organic and inorganic solids suspended in water. Turbidity, a measure of the ability of light to penetrate water, is generally closely associated with TSS. TSS is an important indicator of the overall condition of a stream and health of watersheds. Storms, changes in land management practices, or release of water from storage can increase erosion, resulting in high turbidity. Applying irrigation water high in TSS may reduce infiltration rates, making soils less permeable. Fine sediment in streams also may harm aquatic life by reducing visibility and growth of food organisms, clogging spawning gravel, and by abrading the gills of fish and other organisms. TSS is easily removed through filtration and settling, so there is no public drinking water limit. However, water treatment costs increase with TSS concentration—especially if the material is fine silt and clay.

**Dissolved oxygen (DO).** Higher forms of aquatic life require dissolved oxygen to survive. The DO concentration observed in water is the result of a balance between complex stream processes that deplete or enrich DO.

Excessive nutrients and the introduction of organic materials may deplete DO in streams. Because the amount of dissolved oxygen that water can hold depends upon temperature and pressure, DO may vary with depth. Dewatering and removal of riparian vegetation may also reduce DO since an increase in water temperature reduces the capacity of water to dissolve oxygen. DO enrichment can result from photosynthesis by aquatic plants. DHES's dissolved oxygen standard for protecting warm water aquatic life is 5.0 ppm, and 7.0 ppm for cold water organisms.

**Water temperature.** Some tributaries to the Milk River have average summer water temperatures of 68°-72°F, but most of the lower Missouri River basin streams are warm water streams. These streams freeze during the winter, and maximum temperatures are reached by July and early August. Maximum water temperatures are often 75° to 80°F with occasional peaks above 80°F. Streams begin cooling rapidly in early September and continue until December when freezing may occur. In warm water prairie environments streams meander slowly and tend to have large deep pools and short riffles. These conditions help maintain sufficient water depth for fish when flows dry up, and sometimes provide enough depth for fish to winter over.

**pH.** The acidity of water is measured on a pH scale with neutral conditions indicated by pH 7. Surface-water pH typically varies from about 6.4 (slightly acidic) to 8.4 (slightly alkaline) and conditions outside that range may indicate unusual geochemical conditions of concern to all water users.

Water in the lower Missouri River basin shows a wide range of variation in pH with most in the range of about 7 to 9. Many of the smaller tributaries show a seasonal cycle in pH; groundwater-fed base flows range between 8 and 9. Spring and summer runoff, with a greater proportion of acidic snowmelt and rainfall, have a pH range of about 6.7 to 8.

The acidity of water influences its corrosiveness and ability to dissolve and precipitate minerals. The availability of plant nutrients necessary for healthy growth of crops is strongly affected by the pH of the soil and soil solution. At pH above about 8.4, many necessary nutrients are unavailable for plant growth. Water that is too acidic can corrode water supply works. Conversely, water that is too alkaline can generate scale and interfere with drip irrigation systems and municipal water works. The solubility, mobility and availability of many toxic trace elements, including arsenic, selenium, and boron, and heavy metals (e.g., lead, cadmium, and copper) are controlled by pH.

### LOWER MISSOURI RIVER BASIN

The main-stem Missouri River has the highest quality water and supports the greatest number of beneficial uses in the lower Missouri River basin. Tributaries generally have poorer water quality that is marginal even for less restrictive uses such as irrigation. Tributary flows generally are high in dissolved solids, sodium, SAR, sulfates, and some trace elements (Appendix E).

Regulation by Fort Peck Reservoir has dramatically reduced sediment loads in the channel reach below the dam. However, channel erosion and tributary inflow progressively increase the sediment load with distance downstream from the dam (Figure 4-10). Flow regulation has evened out seasonal variation in dissolved solids concentration in this portion of the river.

As warmer silt-laden waters from the Milk and Poplar rivers flow into the Missouri River, the main stem gradually regains its normal warm, turbid characteristics. Water quality is slightly to moderately impaired by turbidity, suspended sediment, nutrients, iron, and arsenic. However, the Missouri River's moderate salt load and small SAR make the water suitable for irrigation (FAO 1985).

The Redwater River and Poplar River are the largest tributaries in the lower Missouri River basin and each contributes poor quality water to the Missouri River.

Comprehensive water quality monitoring was initiated in the Poplar River drainage in the mid-1970s due to concern over the potential effects of coal-fired power generation in the Canadian portion of the drainage. Coal mining, coal-fired electric generation, and water storage near Coronach, Saskatchewan might adversely affect downstream water quality in the Poplar River. Water quality constraints include elevated sulphate, nutrients, pH, sediment, dissolved solids and boron. Ten years of monitoring (PRBMC 1991) on the East Fork Poplar River (near the International Boundary) show that dissolved-solids and boron concentrations are approaching limits of suitability for irrigation of alfalfa and barley (Figure 4-11).

### MILK RIVER SUBBASIN

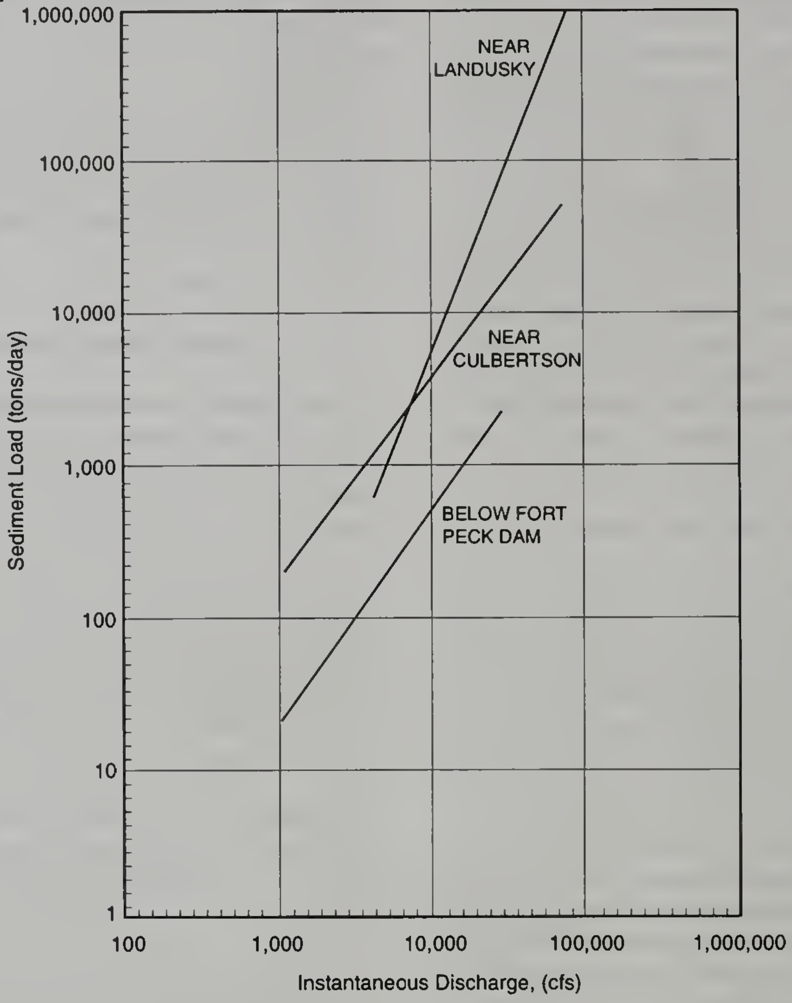
Appendix E gives the range of measured values of water quality parameters for streams in the Milk River subbasin. Existing water quality problems in the subbasin are summarized in Appendix E (DHES 1992). Water quality in the upper Milk River (St. Mary's drainage) is good and is classified B-1. Upon reentry into the United States and for the rest of its length the Milk River is classified B-3. High quality water diverted from the St.Mary's basin into the Milk River subbasin picks up salt and sediment as it flows through a badland reach extending about 150 miles upstream from Fresno Reservoir.

Between Fresno Dam and Nashua, high water temperatures and high levels of suspended sediment, turbidity, and dissolved solids along with reduced dissolved oxygen, contribute to moderate impairment of water quality. Sediment, salts, and other chemical constituents accumulate in this lower section of the river. DNRC closed portions of the Milk River to new water permit applications in 1983 and closed other portions in 1991, because of cumulative water quality impacts on the stream, International Boundary Water Treaty concerns, and severe water shortages.

Water quality in Milk River tributaries varies greatly with season and annual cycles of climate. Suspended-sediment and turbidity levels in the Milk River tributaries increase during high spring flows, and salinity is reduced. At low flows the pattern is reversed. Most tributaries frequently go dry or experience periods of near zero flow, especially during the winter.

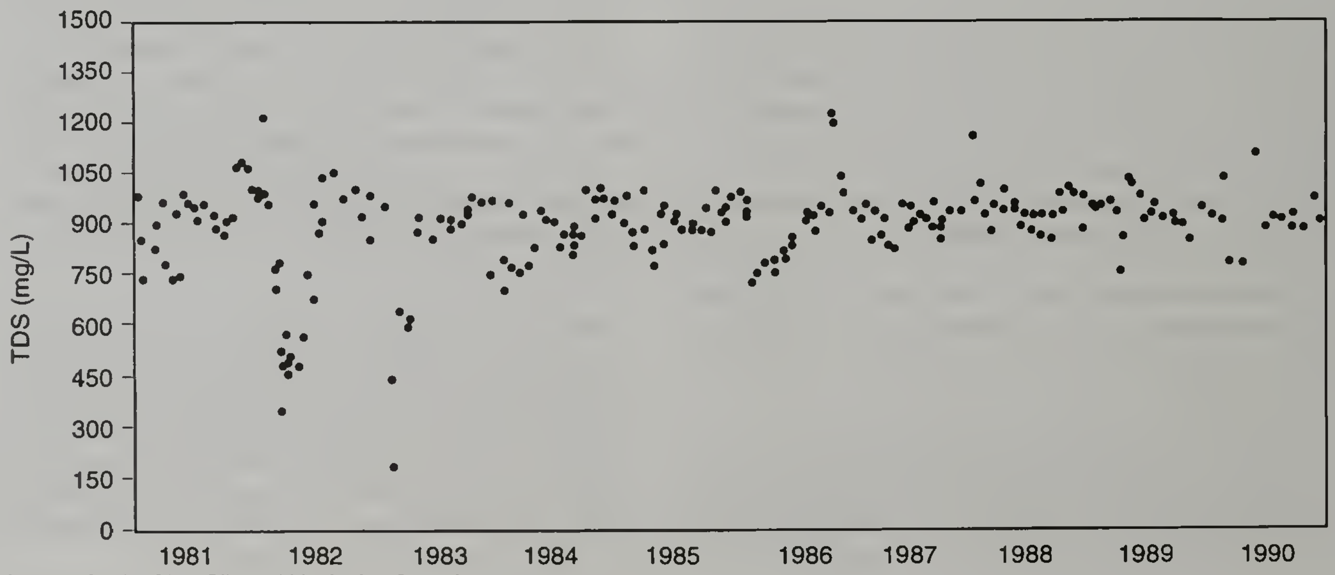
Clear Creek, Little Beaver Creek, Beaver Creek (Hill County) and the upper portions of Big Sandy Creek, Peoples Creek, and Beaver Creek (Phillips County) are classified B-1. These tributaries are important sources of high quality water to both the Milk River and Missouri River. They gradually change to warm water streams after leaving the mountains and entering the prairie.

**Figure 4-10. Comparison of suspended sediment loads for the Missouri River near Landusky, Culbertson and below Fort Peck Dam**



Source: Adapted from Lambing et al. 1987 and Siagle et al. 1984

**Figure 4-11. Suspended sediment data for the East Poplar River at International boundary for period 1981-90**



Source: Poplar River Bilateral Monitoring Committee 1991

Battle Creek, Frenchman Creek, and Rock Creek enter the Milk River from the north and are classified B-3. These warm water streams have relatively good water quality for prairie streams even though they flow through predominantly saline glacial soils.

### LITTLE MISSOURI RIVER SUBBASIN

The Little Missouri River and its major tributaries—Boxelder Creek, Little Beaver Creek, and Beaver Creek—are classified C-3. Surface waters in the subbasin are a sodium-sulfate type and are hard to extremely hard with moderate to high turbidities (Appendix E). Many of the streams have elevated levels of suspended sediment, total dissolved solids, sodium, sulphate, and phosphorous (DHES 1990).

Like most small prairie streams, the Little Missouri River and its tributaries periodically go dry or experience periods of near zero flow. On Little Beaver and Beaver creeks, these effects are typically greatest in the upper and lower reaches where steep gradients and unfavorable channel conditions limit the formation and maintenance of relatively large permanent pools (Guzevich 1993).

Suitability of water for irrigation use varies seasonally and with annual weather cycles. During periods of low flow (July-March) or extended drought, it's likely that elevated salinity and SAR preclude use of water for irrigation of fine textured soils with high clay content. Investigation in the nearby Powder River basin has shown that the best water available for irrigation is spring runoff, although it is turbid and contains high suspended-sediment loads (Bauder et al. 1990). Conditions probably are similar in the Little Missouri River subbasin.

### SHERIDAN COUNTY GROUNDWATER AREA

**Big Muddy Creek:** Big Muddy Creek and most other streams in the drainage are classified C-3; an exception is Antelope Creek, a small headwater tributary, which is designated B-3. Surface-water quality is similar to that in the adjacent Poplar River basin. Elevated salinity, sodium and boron levels may limit irrigation development and problem soils may require specialized management such as irrigation scheduling to maintain yields and productivity.

An unusual feature of the Big Muddy Creek drainage is the Lake Creek tributary. Lake Creek, which is actually a series of shallow lakes, occupies the ancestral Missouri River valley. About 34 lakes of appreciable size exist in the Lake Creek\Big Muddy Creek drainage. These lakes vary widely in elevation, surface area, volume, sources of recharge and water quality (Donovan 1988). Some lakes are entirely "closed" (no significant throughflow of water) or have "restricted" throughflow with evaporation creating highly saline water. Other lakes receive and transmit surface and/or groundwater flow more freely, and these "open" lakes have significantly lower concentrations of salts. Most of the lakes have volumes less than 2,000 af. Medicine Lake, the largest of the open lakes, has a volume of about 88,000 af. In spite of its size and throughflow, Medicine Lake has concentrations of TDS in the range 1,000 to 1,500 ppm.

Many of the lakes in the Lake Creek tributary are within the Medicine Lake Wildlife Refuge and managed by the USFWS for wildlife enhancement and waterfowl production. Maintenance of adequate water quality in the lakes is an important part of the USFWS management program, and lakes are flushed with surface runoff and surface inflows whenever possible (Donovan 1988). For example, spring runoff from Big Muddy Creek is diverted to fill Medicine Lake and Homestead Lake. Water is drained from the lakes later in the year to provide storage capacity for the next year's runoff.

Groundwater in Sheridan County is an important source of water for irrigation use and maintenance of wildlife habitat. Water can be produced from deep aquifers and shallower unconsolidated alluvium and glacial outwash (Levings 1986; Donovan 1988). The Fox Hills-lower Hell Creek aquifer yields little water and it is of poor quality because of elevated salt and sodium. Groundwater from the Fort Union Formation is also generally unsuited for domestic use or irrigation.

Unconsolidated units consist of terrace gravels, glacial outwash, glacial till, and recent alluvial deposits. Outwash aquifers in the area yield relatively large volumes of water, much of which is of sufficient quality for irrigation (typically TDS less than 1,000 ppm and SAR less than 5). Water from outwash aquifers varies in quality primarily due to the source and amount of recharge. Although the outwash aquifers generally have the best water quality of all the local sources, elevated salinity, sodium, and bicarbonate may still limit suitability for irrigation use. At least two irrigation systems have been abandoned due to salinity/infiltration problems caused by SAR of 13.6 and 15.2 (Donovan 1988). Systems operating with a SAR in the range of 10-12 require careful management and application of water only on well-drained sandy soils.

Groundwater in glacial outwash deposits may be very high in iron with concentrations over 5 ppm common (Donovan 1988). Elevated iron concentration causes iron bacteria and precipitate problems for wells; it also may contribute to soil acidification and affect the uptake of essential plant nutrients and trace-elements (FAO 1985).

Montana Water Quality Standards and the federal drinking water standard limit domestic water supplies to nitrate-nitrogen ($NO^-_3$-N) concentrations of 10 ppm (as N). Nitrate is present in shallow aquifers in the area and is especially high in groundwater of the Flaxville gravel where concentrations may exceed 50 ppm (as N) (Donovan 1988). A recent statewide survey of 3,400 private wells found that 6 percent had nitrate-nitrogen levels in excess of 10 ppm (as N), which is similar to the national average (Bauder et al. 1993). However, about 50 percent of the elevated samples were obtained from seven counties. The highest average nitrate-nitrogen concentrations were found in Sheridan county (7.3 ppm $NO^-_3$-N) and Roosevelt county (7.1 ppm $NO^-_3$-N).

# SOILS

## LOWER MISSOURI RIVER BASIN

Soil types in the lower Missouri River basin have been categorized by their relation to three dominant landforms: glaciated upland plains, nonglaciated upland plains, and floodplains and low terraces.

Glaciated uplands cover almost the entire area north of the Missouri River valley and also the land to about 20 miles south. Soils in this type of terrain were formed mostly from glacial till, but also from soft shales, sandstones, siltstones, and claystones. The soils are generally deep and well-drained loams, sandy loams, silty loams, and clay loams. Because the glaciers transported lots of rock into the area, much of the soil is stony. Some of these soils contain high amounts of calcium carbonate. Soil permeability is generally moderate, and water-holding capacities are high. In general, the soils are moderately susceptible to water erosion and moderately to highly susceptible to wind erosion. In some higher bench areas—the uplifted remnants of old stream channel terraces—soils are gravelly and water drains through them rapidly.

Nonglaciated uplands cover the southernmost portion of the subbasin. Soils here were formed from weathered sandstones, siltstones, and claystones. These soils are generally moderately deep and well-drained loams, and silty and sandy loams. Soil permeability and water-holding capacities are in the moderate range. In general, these soils are moderately susceptible to water erosion and moderately-to-highly susceptible to wind erosion.

Floodplains and low terraces occur along rivers and streams in the subbasin with those along the Missouri River the largest by far. Soils in these landforms are made up of materials that have been transported, reworked, and deposited by streams. They are generally deep and moderately-to-well-drained loams, and silty, sandy, and clayey loams. However, locally the soils can range from very sandy to clayey and some saline soils also are present. Soil permeability is generally slow to moderate, and water-holding capacities are moderate to high. Poor drainage on some excessively saline and clayey soils can cause water to pond on the surface. The susceptibility of these soils to water erosion is for the most part low, and they are moderately susceptible to wind erosion.

## MILK RIVER SUBBASIN

For the purpose of describing soils, the Milk River subbasin can be divided between the floodplains of the Milk River and its larger tributaries, and the surrounding uplands.

Most of the uplands in the subbasin were once covered by glaciers and, consequently, the soils usually are derived from glacial till and meltwater deposits. Other soils in the subbasin were formed from eroded local bedrock, primarily soft shales and sandstones. Most of these upland soils are deep, well-drained loams, and clay loams, but some local soils are sandy. Stones are common in the soils and were transported to the area by the glaciers. Water tends to move slowly into these soils, although their water-holding capacity is usually moderate to high. The susceptibility of these soils to water erosion is generally a function of slope—high erosion is more likely on steep slopes than on flatlands. Most soils here are moderately susceptible to wind erosion.

Floodplain soils in the subbasin were derived from sediments transported, reworked, and deposited by the Milk River and its tributaries. Generally, they are composed of loams and silty and clayey loams. Water usually seeps into these soils slowly and water-holding capacities are moderate to high. However, some areas contain clayey and salty soils, which drain poorly and hold little water that is available to plants. The susceptibility of these soils to water erosion is generally low, and for the most part they are moderately susceptible to wind erosion.

## LITTLE MISSOURI RIVER SUBBASIN

Soils in the Little Missouri River subbasin fall into three categories: fine upland soils, coarse upland soils, and floodplain soils. In contrast to the other subbasin soils, no soils in the Little Missouri River subbasin are derived from glacial materials.

Fine upland soils are located in areas where the bedrock is primarily shale and siltstone. These soils are generally deep and well-drained loams, silty loams, and clayey loams. Water generally seeps into these soils slowly, and their capacity to hold water generally is moderate. These soils are susceptible to water erosion, especially where slopes are steep. In general, their susceptibility to wind erosion is low. Some of these soils are alkaline and have high concentrations of salts, limiting their usefulness as cropland.

The coarser upland soils in the subbasin were formed from sandstones. They are generally shallow to moderately deep, sandy loams and well-to-excessively drained. Water generally seeps rapidly into and through these sandy soils. Because water seeps into them rather than running off the surface, these soils generally are resistant to water erosion. However, they are highly susceptible to blowing.

Floodplain soils in this subbasin usually are deep, sandy loams, loams, and silty loams. The permeability of these soils is moderate-to-rapid, and water-holding capacities range from low to high. Because these soils are generally located on flat floodplains, water erosion hazards from rain and runoff are low, although the soils are susceptible to streambank erosion. Where soils are sandy, the wind erosion potential is high. These soils usually contain moderate amounts of organic matter.

## SHERIDAN COUNTY GROUNDWATER AREA

Soils in this area were developed from glacial till, meltwater deposits, and windblown sediments. The till-derived soils are generally deep loams and clayey loams. Water moves slowly into these soils, but usually they can hold lots of it and the water is available to plants. They generally are well-drained soils, but on some excessively saline and clayey soils the drainage is poor and water tends to pond on the surface. Soil drainage problems in this subbasin are often compounded by a high water table. Subbasin soils derived from glacial outwash and windblown deposits are generally sandy loams. Water can quickly percolate into these soils, but their water-holding capacities are low. These sandy soils are susceptible to blowing. Soils along Big Muddy Creek were derived from stream-transported sediments. Drainage is poor on some of these often clayey and sometimes salty soils.

## SALINE SEEPS

Saline seeps are localized wet areas with salt-encrusted, 'slick soils. Saline seeps begin when precipitation percolates through salt-laden soils. As the water percolates, it dissolves the salts and carries them to the water table. Saline seeps occur where the salty groundwater discharges and ponds on the surface.

Saline seeps are a problem throughout the lower Missouri River basin (Table 4-5). Saline seeps can destroy agricultural land and degrade the water quality of aquifers, springs, small streams, and reservoirs to the point where the water is unusable for humans or livestock.

Saline seeps sometimes occur naturally, especially where soils are formed from glacial till, but dryland farming using the crop-fallow rotation system that is common in eastern Montana has created most of the saline seep problem. This is because moisture accumulates and begins to move through the soil in the fallow fields where water is not being used by crops. Where soil sodium concentrations are high and other conditions opportune, the groundwater will become salty and saline seeps will appear.

Irrigation also can lead to saline seep problems. Irrigating with salty water can increase soil salinity. When the salts are flushed through the soil by irrigation or precipitation, saline seeps can expand. Even when good quality water is used for irrigation, saline seep problems can occur if soils are already salty and water application rates are not properly controlled.

Table 4-5. Estimated acres of saline seeps by county

| County | Acres affected |
|---|---|
| Blaine | 3,000 |
| Daniels | 5,400 |
| Fallon | 715 |
| Hill | 2,000-2,500 |
| Liberty | 4,600 |
| McCone | 10,000 |
| Phillips | 1,000 |
| Richland | 1,900-3,500 |
| Roosevelt | 12,500 |
| Sheridan | 10,000-12,000 |
| Wibaux | 300 |

Source: DHES 1974

## STREAM CHANNEL FORM

Along with water, streams carry sediment—and often lots of it. Sediment can enter a stream in many ways. Soil eroded and carried by surface runoff during heavy rainstorms may eventually reach a stream channel. Streams also erode sediment from their beds, or sediment can enter as eroding banks crumble and collapse into the stream. Also, streams can pick up sediment by lengthening or "headcutting" their way upslope, an often destructive process that is sometimes called "gullying."

Once in the stream, finer sediments, such as clay and silt, usually move as suspended particles, giving river water a muddy appearance. Larger materials, such as sand, gravel, rubble, and even boulders, roll, slide, and bounce down the streambed. Basin characteristics, such as climate, topography, and geology, determine the sediment supply of a stream. The sediment supply along with the timing and volume of streamflows, also called the "flow regime," helps shape the stream channel and bed.

Most streams in the lower Missouri River basin meander through channels of alternating pools and riffles. Pools are usually located on the outside bends of meanders where the water is deeper and current slows as water piles up against the streambanks. Riffles occur where the current crosses the channel between pools and are generally shallower than the pools and with swifter flows. Over time, meanders will migrate, usually downstream.

Channel migration is important; it rejuvenates and maintains healthy riparian ecosystems. Also, the riffle-pool sequence of a stream provides habitat for fish and other aquatic life. For instance, the relatively deep pools of prairie streams are crucial in sustaining fish during the late summer, fall, and winter, when flows over riffles can drop to a trickle or even cease. Aquatic life is also supported by other features associated with the stream channel, such as streamside vegetation that provides shade.

It has been suggested that the discharge of the stream when it is brim full bank-to-bank, "bankfull discharge," is primarily responsible for forming and preserving the stream channel. Advocates of this hypothesis argue that streams are most effective at eroding and transporting sediments at these flows, and that bankfull discharge occurs frequently enough, usually every 1 to 2 years, to do much of a stream's work. Although bankfull discharges play a crucial role in maintaining the stream channels, the hypothesis oversimplifies a natural process; streams probably not look the same if they flowed bankfull only once every one or two years. Indeed, research has shown that channel characteristics do not always relate well to bankfull discharge (Knighton 1984), suggesting that a combination of occasional bankfull discharges and other flows throughout the year may be needed to maintain the stream channel.

Others believe that infrequent large floods or "gully washers" are primarily responsible for eroding and shaping the stream channel. But although these floods may individually erode and transport great amounts of sediment, they occur too infrequently to have a great cumulative effect on long-term channel characteristics.

Human activities that divert and deplete flows, change flow regimes, block sediment movement, or physically modify the streambed can alter stream channel characteristics and ultimately affect the habitat and food supply for fish and wildlife. In some cases, diverting water from streams has resulted in the deposition of sediments, growth of vegetation in the stream channel, and a subsequent reduction in stream channel area (Wesche et al. 1988). On the other hand, damming of the Missouri River has trapped sediment and caused the stream to scour and widen its channel (Williams and Wolman 1984). Some streams in the basin have been affected by the use of rip-rap, channelization, and other measures intended to stabilize or straighten stream channels and banks.

### LOWER MISSOURI RIVER BASIN

The Missouri River is the dominant stream in this subbasin. It is wide, shallow, and its streambed and banks are composed primarily of fine sand, silt, and clay. Although the stream meanders for most of its length, the channel also braids through numerous islands and sandbars. Fort Peck Dam changed the Missouri River and its channel after impoundment began in 1937.

Prior to the dam, the river carried a much heavier sediment load and often flooded its banks. Stream meanders actively migrated, especially during times of high flow. Today, most of the river's sediment is trapped in Fort Peck Reservoir and flooding is rare. The clear river water, now with a great capacity for sediment, is eroding the river banks and bed—the only sources of sediment available to it besides that contributed by tributaries. The average annual sediment load of the river increases from near zero at Fort Peck Dam to 5 million tons a year at Culbertson (Corps 1986). The streambed and banks are the source of much of this sediment. Since the dam was closed, the river has eroded into its bed as far as 6 feet in some areas (Williams and Wolman 1984).

In the upper sections of the stream, this scouring has in places removed much of the fine sediment from the streambed, leaving only coarser gravel, rubble, and boulders. On the positive side, additional scouring of the bed in these areas will be limited because the coarse materials now armor the stream channel from further erosion. Bank erosion is causing the river channel to widen in some sections. The scouring and channel widening is likely to continue for some time while the stream adjusts to its altered state.

It has been suggested that bank erosion along the river is intensified by daily streamflow fluctuations associated with hydropower peaking operations at Fort Peck Dam. Up to twice as much water is released from the dam when electricity demands are greatest, usually during the late afternoon and evening, than at times of low demand. When flows are higher, water from the rising river can move into streambank sediments. Then, when releases from the dam are cut back and the river level drops, the direction of water flow in the banks reverses—from the banks toward the stream. This creates water pressure against the banks, which in a sense pushes them toward the river, a process which may eventually cause the banks to fail and crumble into the stream. Freezing and thawing of water in the banks during the winter may further accelerate this phenomenon.

Plant roots reinforce streambanks. Removal of trees and other vegetation along the Missouri River as fields are cleared for agriculture has left river banks more susceptible to erosion. Irrigation return flows can saturate banks and thereby cause them to fail.

Other streams in the lower Missouri River basin include the Poplar River and its tributaries and the Redwater River. These Missouri River tributaries are prairie streams with channel characteristics similar to streams in the Milk River subbasin. Many streams draining into the Missouri River from the north, such as the Poplar River, occupy the channels of what were at one time much larger glacial meltwater streams.

## MILK RIVER SUBBASIN

Streams in the Milk River subbasin are primarily low-gradient prairie streams. Except during floods, they are slow flowing and characterized by long, relatively deep pools broken by shorter, shallow riffles. Streambeds here are composed mostly of silt and sand, but coarser gravel and cobble also are present, especially in riffle sections. Much of this gravel and cobble originated from materials that were transported into the area by glaciers thousands of years ago. Some prairie streams in this subbasin include Battle, Sage, Big Sandy, Rock, and Frenchman creeks.

The Milk River itself meanders through the wide ancestral valley of the Missouri River—the Missouri having been pushed to its present position by continental glaciers. The Milk River's bed and banks are composed primarily of silt, clay, and sand.

Fresno Dam and numerous water diversion projects have changed the Milk River. The channel has narrowed downstream from the dam and the rate of meander migration has slowed markedly (Bradley and Smith 1984). Flooding now occurs less frequently. However, the Milk River is still a major source of sediment for the Missouri River.

Some streams in this subbasin originate in mountainous areas and are characterized by faster flows, more closely spaced pools and riffles, and coarser streambed and bank materials. Examples include streams that originate in the Bears Paw and Little Rocky mountains, such as Beaver Creek in Hill County, Beaver Creek in Phillips County, Clear Creek, and Little Box Elder Creek.

## LITTLE MISSOURI RIVER SUBBASIN

Streams in this subbasin include the Little Missouri River, and Beaver, Little Beaver, and Boxelder creeks, and their tributaries. All are meandering prairie streams, with the exception of some small tributaries, which originate in the wooded hills near Ekalaka and Long Pines. Although the streams have low gradients, flows can be swift, high, and murky, especially during spring runoff and after summer rainstorms. Most of the smaller tributaries are dry except during spring runoff or following storms, and even in the four major streams flows, often decline to a trickle or cease. Standing water usually will remain in the deeper pools of the larger streams, even during times of drought. This underscores the importance of these pools to the aquatic life in these streams.

Streambanks in this subbasin range from steep to gently sloping. Some tributary streams have eroded deep gullies, while other channels are discontinuous, or at least hard to discern. Badlands, which are formed by gully erosion in combination with other water-related erosive forces, occur in portions of this subbasin. Some of the larger streams, notably the Little Missouri River, meander through relatively wide alluvial valleys.

Because erosion rates in this subbasin are high, the streams often transport lots of sediment. However, much of this sediment is redeposited farther downstream in the stream channels and on the floodplains. Streambeds are primarily composed of sands, silts, and clays, but it is also common to find coarser gravel and rubble, especially in the beds of the larger streams.

### SHERIDAN COUNTY GROUNDWATER AREA

The dominant stream in Sheridan County is Big Muddy Creek, a large ephemeral stream, which occupies a former glacial outwash channel. The area to the east of Muddy Creek, where the proposed irrigation projects are located, is characterized by prairie pot-hole lakes, a poorly developed surface drainage system, and consequently, a general lack of stream channels.

## VEGETATION

The northern Great Plains and its associated plant communities cover most of the lower Missouri River basin study area. The environment here is often harsh: precipitation is low, temperature extremes are great, and strong winds are the norm. Nevertheless, hardy grasses thrive, and forbs, shrubs, mosses, lichens and cactus are abundant and widespread. Wooded areas occupy only narrow ribbons of land, usually adjacent to rivers and streams. The few mountainous tracts in the basin, with their pine forests and lush meadows, stand isolated as dark green islands above the prairie.

The vegetation in the study area today is quite different from that present prior to European settlement. Conditions in much of the basin are well suited for growing small grains and, hence, large tracts of the prairie are now plowed to produce annual crops such as wheat, barley, and oats. In the stream valleys, land has been developed for irrigation. Much of the forest along the major river courses has been cleared, first to stoke the boiler furnaces of steamboats plying the Missouri, and later to make way for farming. Also, a host of introduced grasses and forbes—for better or for worse—have probably become a permanent part of the local plant communities.

This section describes some of the more common plant communities and representative species found in the study areas, but makes no attempt to identify all of the thousands of plant species found in the lower Missouri River basin.

### UPLAND PRAIRIE

Most of the lower Missouri River basin is upland prairie where grasses are the predominant plants. Common grasses found on good condition native range include green needlegrass, western wheatgrass, rough fescue, little bluestem, prairie sandreed, and needle-and-thread. Where range conditions are not as good, or overgrazing has occurred, grasses such as blue grama, sandberg bluegrass, prairie junegrass, cheatgrass, and Kentucky bluegrass become more prevalent. Clubmoss, fringed sagewort, cactus, threadleaf sedge, weeds, and shrubs such as sagebrush and greasewood also are common on upland prairie sites and often indicate poorer rangeland.

### MOIST PRAIRIE

Moist prairie generally occurs near streams or on upland sites where drainage is poor and water concentrates near the surface. The prairie-pothole area in eastern Sheridan County, topography that was formed when the last glaciers retreated over 10,000 years ago, includes much moist prairie. Plants typical of moist prairie sites include grasses such as prairie cordgrass, sloughgrass, bluejoint reedgrass, curly dock and foxtail barley. Sedges and rushes are also widespread and shrubs like shrubby cinquefoil, wild rose, silver sagebrush, and rabbitbrush are locally abundant. Many areas in the prairie-pothole region in Sheridan County are saline, and the plants surrounding them are adapted to the salty conditions. Grasses such as alkali cordgrass, inland saltgrass, western wheatgrass, and Nuttal alkaligrass, and shrubs like Nuttal saltbush and greasewood, are indicative of saline conditions.

## BREAKS

Breaks are rough, dissected lands with steep slopes where upland prairies give way to river and stream valleys. This category also includes badlands, which are common in the Little Missouri River subbasin. Many of the plant species found in upland prairies sites are present in the breaks, although plant cover in the breaks usually is more sparse. Grasses found in breaks include western wheatgrass, thickspike wheatgrass, needle-and-thread, and bluebunch wheatgrass. Shrubs such as sagebrush and greasewood also are found, as are forbes, cactus, moss, and lichens. Some breaks also contain larger woody vegetation like juniper and ponderosa pine.

## MOUNTAINOUS AREAS

Mountainous areas in the basin include the Bears Paw and Little Rocky mountains in the Milk River subbasin, and the Ekalaka and Long Pine hills in the Little Missouri River subbasin. Some mountain slopes and riparian areas along streams are heavily wooded. In other places, the forests are more open with an understory of shrubs and grasses. Areas of open pasture and shrubland also are common. Ponderosa Pine, lodgepole pine, and Douglas fir are common conifer trees in the Bears Paw and Little Rocky mountains. In the Ekalaka and Long Pine hills, forests are dominated by ponderosa pine and juniper. Mountainous riparian areas may contain both conifer species and deciduous trees such as quaking aspen. Shrubby vegetation found in the forest understory and more open areas and draws includes Saskatoon serviceberry, kinnikinnick, chokecherry, common snowberry, shrubby cinquefoil, and silver sagebrush. Grasses found in mountainous areas, both on forested and exposed terrain, include rough fescue, bluebunch wheatgrass, green needlegrass, and basin wildrye.

## WOODED DRAWS

Woody draws are isolated wooded gullies on the open plains. Most commonly, woody draws are occupied by a small ephemeral creek, but they also occur in other sheltered areas where water is present at least part of the time, such as springs and seeps, and on some hillside pockets where drifting snow and runoff collect.

The largest plants in woody draws are small trees, primarily box elder and green ash, and sometimes plains cottonwood and American elm. Shrubs are abundant in woody draws and include chokecherry, buffaloberry, wild plum, wild rose, western snowberry, red osier dogwood, western serviceberry, wild grape, currants, and gooseberry. Common grasses include western wheatgrass, green needle grass, and Kentucky bluegrass.

The forage and especially the cover provided by woody draws is important to wildlife inhabiting the open plains. Swenson (1981) found that even though wooded draws represent only about 1 percent of the total area of southeastern Montana, these areas are second only to river-bottom woodlands in overall productivity, diversity, and importance to wildlife.

## BOTTOMLANDS

Bottomlands are flat lowlands adjacent to the larger rivers in the basin. Plant communities in bottomlands include woodlands, shrub/scrub land, mixed prairie (grasslands with trees that are scattered or clustered in groves), marsh, and prairie. Bottomlands trees include plains cottonwood, green ash, boxelder, peachleaf willow, and sometimes American elm. Bottomland shrubs, both in the forest understory and more open areas, include western snowberry, red osier dogwood, silver buffaloberry, Saskatoon serviceberry, wild plum, chokecherry, wild rose, and silver sage. Grasses growing in both the forest understory and prairie include green needlegrass, prairie sandreed, prairie junegrass, smooth brome, and western wheatgrass.

Because bottomland soil usually is quite productive, much of the native vegetation has been removed to make way for crops. The levelness of bottomlands and their proximity to water have also made them ideal sites for irrigation.

The largest bottomlands in the study area by far are along the Missouri River between Fort Peck Dam and the North Dakota border. There are some concerns regarding plant communities in these bottomlands, particularly the cottonwood forests.

Flooding is important to cottonwood regeneration because the silt and moisture it provides benefit seed germination and may also help sustain young trees until their roots grow long enough to tap the water table. Flooding also helps to disperse cottonwoods and willows. Since the construction of Fort Peck Dam, overbank flooding along the Missouri River in Montana has for the most part been eliminated (some limited overbank flooding still occurs due to ice jamming.)

Another process important to cottonwood forest regeneration is channel migration, the rate of which probably has decreased since the closure of Fort Peck Dam. As channel meanders migrate (see Stream Channel Form section) streambanks are eroded and the trees and other plants on these banks are destroyed. At other places, however, streambanks are built where sediment is deposited by the river. Plains cottonwood and peach-leaved willow are usually the first trees to become established on these freshly deposited sediments. As the forest ages, the cottonwood and willow eventually die and are replaced by green ash, boxelder, and sometimes American elm. Without a continual reworking of the valley sediments by the meandering river, the cottonwood forest in time could disappear.

Johnston et al. (1976) hypothesized that the lack of young stands of plains cottonwood along the Missouri River below Garrison Dam in North Dakota—an area similar to the lower Missouri River valley in Montana—was a result of decreased migration of river meanders and poor seedbed conditions in the absence of overbank flooding, both resulting from impoundment of the river at Garrison Dam.

Stabilizing channel banks with riprap and other materials also can constrain meander migration and pose a threat to riparian vegetation, especially the cottonwoods. At present, only a small percentage of streambank on the lower Missouri River in Montana has been stabilized. In other states along the lower Missouri River, more extensive bank stabilization by the Corps of Engineers has limited channel migration (Schmudde 1963).

The deepening of the Missouri River streambed since the completion of Fort Peck Dam is another threat to the cottonwood forests. A deeper stream bed could lower the water table below the point were it can be reached by tree roots.

Farming also is a threat to the bottomlands plant communities. Both Hoar and Erwin (1985) in Montana, and Johnson et al. (1976) in North Dakota documented that much of the floodplain that formerly supported riparian vegetation along the Missouri River has been cleared for farming. This conversion of riparian plant communities to cropland continues today.

As part of this EIS, the vegetation composition of bottomlands in the lower Missouri River valley was mapped using information from the most recent comprehensive aerial photographic coverage of the area (photographs from the summer of 1991). Appendix F contains maps of the existing vegetation in bottomlands along the Missouri River. The acres of each vegetation category are given in Table 4-6.

**Table 4-6. Existing lower Missouri River valley bottomland plant communities (acres)**

| | |
|---|---|
| Woodland | 26,584 |
| Shrub/scrub land | 8,795 |
| Mixed prairie (grasslands with scattered trees or small groves of trees) | 19,066 |
| Prairie | 19,754 |
| Marsh | 2,046 |
| Irrigated cropland | 43,006 |
| Nonirrigated cropland-grain | 62,367 |
| Nonirrigated cropland-hay | 5,252 |
| Urban | 898 |
| Total | 187,768 |

The results of this analysis are further summarized in Table 4-7 to make them comparable to an earlier vegetation mapping study of the valley conducted by Hoar and Erwin (1985). These comparisons indicate that the proportion of agricultural land in the valley has steadily increased at the expense of some bottomland plant communities. The acreage of shrub/scrub land and mixed prairie have been reduced most extensively. Woodlands in the valley increased from 1938 to 1974 and then declined until about 1983. During the past decade, the amount of woodland has remained relatively stable.

**Table 4-7. Vegetation of the Missouri River floodplain below Fort Peck Dam by era (percentage)**

| Year | Agriculture[a] | Rights-of-way | Urban/ ranchyard | Woodlands | Shrub/ scrub | Mixed prairie[b] |
|---|---|---|---|---|---|---|
| 1938 | 24 | 0.2 | 0.6 | 10 | 14 | 52 |
| 1956 | 47 | 0.4 | 0.9 | 16 | 11 | 25 |
| 1974 | 51 | 0.5 | 1.0 | 20 | 7 | 21 |
| 1982 | 55 | 0.5 | 0.8 | 13 | 5 | 26 |
| 1991 | 58 | [c] | 1[b] | 14 | 5 | 22 |

[a] Agriculture includes the irrigated cropland and nonirrigated cropland categories from Table 4-6.

[b] Mixed prairie includes the prairie, mixed prairie, and marsh categories from Table 4-6.

[c] Rights-of-way were not delineated for 1991 data

[d] Only includes urban land

## SENSITIVE PLANTS

Although there are many species of plants in the lower Missouri River basin, the diversity of plant communities may be diminishing. Some types of plants are declining both in numbers and distribution. The Montana Natural Heritage Program has identified rare Montana plants so that resource managers can assess the potential effects of development on these plants. Table 4-8 lists 17 rare plants that are found in the lower Missouri River basin. No Montana plants are listed as threatened or endangered under the U.S. Endangered Species Act.

## NOXIOUS WEEDS

Noxious weeds are undesirable plants that can infest cropland and have little or no value as forage for livestock and wildlife. Because most noxious weeds were introduced to this continent from elsewhere, they have few natural enemies here and therefore tend to out-compete native plants. If not controlled, noxious weeds spread rapidly. Disturbed land, such as heavily grazed pastures, fallow fields, and corridors for roads, pipelines, and transmission lines, are particularly susceptible to weed infestations.

The Montana Department of Agriculture has designated 15 plants as noxious weeds (Table 4-9). Local weed control districts also may target other weeds in their control programs. Weeds that are a serious problem in the lower Missouri River basin include leafy spurge, knapweed (spotted, diffuse, and Russian), Canada thistle, whitetop, and field bindweed.

## RIPARIAN LAND AND WETLANDS

Riparian land usually contains woody vegetation and other plants typically not found in drier uplands. They generally occur in the alluvial areas bordering streams, such as in the bottomland and woody draw vegetation associations described above. The relatively high water table and periodic flooding and migration of stream channels in these areas is important in maintaining riparian ecosystems. Riparian land is usually quite productive, and provides important habitat for wildlife. Wetlands occur within riparian land, but not all riparian land is generally considered wetland.

Wetlands are at least seasonally flooded, or have a water table at or very near the surface. Plants that grow in wetlands are adapted to saturated soil conditions. Rushes, sedges, cattails, and reed canarygrass are some plants that are indicative of wetlands in Montana. Wetlands also can be distinguished by their soils which, because they were developed under saturated conditions, are quite different than those typical of drier areas. Marshes, swamps, bogs, sloughs, potholes, stream overflow areas, and some wet meadows are classified as wetlands.

Wetlands occur in moist upland prairie areas and are especially common in the prairie pothole region of eastern Sheridan County. Other areas with important wetland habitat in the basin occur near the Missouri River and in lowlands near the Milk River. The USFWS is inventorying the nation's wetlands and classifying them under the Cowardin system (Cowardin et al. 1979). As a result of this effort, wetlands in some portions of the lower Missouri River basin have been delineated and classified.

Wetlands provide crucial habitat for wildlife and fish. Wetlands also store water, trap sediments, and remove nutrients, pesticides, and other toxic substances from runoff. Sheridan County contains the most important wetlands for waterfowl production in Montana (BUREC 1992).

According to Dahl (1990), total wetland acres in Montana have decreased from 1,147,000 to 840,300 since European settlement. Most of this wetland loss has been due to agricultural development. Wetlands also can be lost when local hydrology is modified—for instance, due to lowering of water tables by groundwater pumping. The "Swampbuster" provisions included in the 1985 Food Security and Conservation

**Table 4-8. Sensitive plants that occur in areas where irrigation projects are proposed**

| Species | Status | Subbasins of occurrence | Habitat |
|---|---|---|---|
| Viburnum lentago (Nannyberry) | Sensitive[a] | Lower Missouri | Openings in riparian forests |
| Suckleya suckleyana (Poison suckleya) | Sensitive | Lower Missouri, Milk | Pond and streambanks, disturbed soils |
| Sphenopholis obtusata (Prairie wedgegrass) | Watch List[b] | Little Missouri | Grasslands, valleys, and plains |
| Phlox andicola (Moss phlox) | Watch List | Little Missouri | Grasslands, sandy soil |
| Asclepias stenophylla (Narrow-leaved milk weed) | Sensitive | Little Missouri | Grasslands, sandy soil |
| Dalea villosa (Silky prairie clover) | Sensitive | Little Missouri | Grasslands, sandy and gravelly soils |
| Cyperus schweinitzii (Schweinitz's flatsedge) | Sensitive | Little Missouri, Sheridan Cnty. | Grasslands, sandy soil |
| Penstemon angustifolius (Narrowleaf pensteman) | Sensitive | Little Missouri | Grasslands, sandy soil |
| Haplopappus multicaulis (Many-stemmed goldenweed) | Limited distribution | Little Missouri | Grasslands, clayey soil |
| Astragalus racemosus (Raceme milkvetch) | Sensitive | Little Missouri | Grasslnds, heavy soil |
| Amorpha canescens (Lead plant) | Possibly extirpated[c] | Little Missouri | Grasslands and open woodlands |
| Maianthemum canadense (Wild lily-of-the-valley) | Sensitive | Little Missouri | Riparian forests |
| Linaria Canadensis (Blue Toadflax) | Sensitive | Little Missouri | Grasslands and woodlands, sandy soil |
| Eleocharis xyridiformis (Creeping spike rush) | Sensitive | Little Missouri | Shorelines of ponds, marshes and ditches |
| Cryptantha fendleri (Fendler's cat's eye) | Sensitive | Sheridan County | Sandy areas, plains |
| Carex sychnocephala (Many-headed sedge) | Endangered[d] | Sheridan County | Moist meadows, shores of ponds and lakes |
| Scirpus nevadensis (Nevada bullrush) | Sensitive | Sheridan County | Wet alkaline prairie, muddy shores of alkaline ponds and lakes |

[a] Sensitive plants are those known from a limited number of populations in Montana or occur principally in restricted habitats that are vulnerable to man-caused disturbances.

[b] Plants on the watch list are considered to a common to be listed as sensitive, but more information is needed for certainty.

[c] Recent field searches indicate that these plants, once known to occur in Montana, may not longer occur in the state.

[d] Endangered plants are in danger of extirpation throughout all or a significant portion of their range in Montana.

**Table 4-9. Montana noxious weeds**

**Category 1 (currently established and generally widespread)**

- Canada thistle (*Cirsium arvense*)
- Field bindweed (*Convolvulus arvensis*)
- Whitetop or Hoary Cress (*Cardaria draba*)
- Leafy spurge (*Euphorbia esula*)
- Russian knapweed (*Acropetilon repens*)
- Spotted knapweed (*Centaurea maculosa*)
- Diffuse knapweed (*Centaurea diffusa*)
- Dalmatian toadflax (*Linaria dalmatica*)
- St. Johnswort (*Hypericum perforatum*)

**Category 2 (recently introduced or rapidly spreading)**

- Dyers Woad (*Isatis tinctoria*)
- Purple loosestrife (*Lythrum salicaria* and *L. virgatum*)
- Sulfur (erect) cinquefoil (*Potentialla recta*)

**Category 3 (Not yet detected in the state or found in small, scattered infestations)**

- Yellow Starthistle (*Centaurea solstitialis*)
- Common Crupina (*Crupina vulgaris*)
- Rush Skeletonwood (*Chondrilla juncea*)

SOURCE: Administrative Rules of Montana 4.5.201-203 et seq.

and Trade Act of 1990 may slow the rate of wetland loss. These provisions "deny USDA farm program benefits to any person who converts a wetland by draining, dredging, filling, leveling, or using any other means for the purpose; or to have the effect of making possible the production of an agricultural commodity, or plants an agricultural commodity on a wetland converted after December 23, 1985" (Thompson and Tyler 1991). The Corps has authority under section 404 of the Clean Water Act to regulate the discharge into and dredging and filling of wetlands, but wetlands converted before December 23, 1985, are not covered by the act. Montana is implementing a program to protect its wetlands, but to date has not developed policies for wetland protection.

# LAND USE

## LOWER MISSOURI RIVER BASIN

Tributaries to the Missouri River below Fort Peck Dam drain 17.1 million acres, including 9.4 million acres in the Milk River drainage (Missouri River Basin Commission 1981). Although land uses have changed considerably during the past century, the total amount of land developed for human use has changed little since the 1950s (Frey and Hexen 1985; Fedkew 1989). In eastern Montana, land along transportation routes and the higher quality agricultural land was settled first. Intensive uses, such as commercial, residential, or transportation use generally developed along strategic waterways. The less valuable land (less suitable for agriculture) was left undeveloped (Alig 1990; Wall 1981).

### TRANSPORTATION

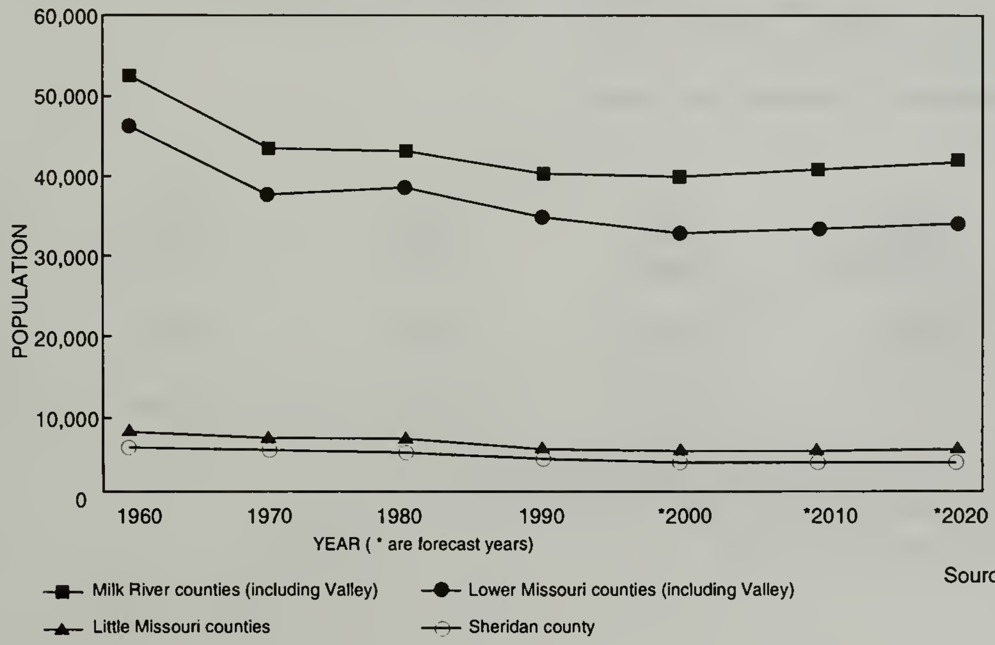
Major transportation facilities, particularly U.S. Highway 2, the Burlington Northern Railroad, and Interstate Highway 94, connect many towns in the basin. Federal and state highways link all area communities to each other and to the larger highways and the railroad.

### POPULATION

The population of the 13 counties in the lower Missouri River basin has declined significantly over the past 30 years, from 96,000 people in 1960 to 77,000 in 1990 (Bureau of Census 1991). This population decline is expected to continue for at least the next decade (NPA DATA, Inc. 1993). The 20 percent decrease in basin population over the past 30 years contrasts to Montana's 18 percent population growth and the 37 percent growth in U.S. population during the same period. Twelve of the 13 counties have lost population over the past three decades (a combined average loss rate of 0.9 percent per year), while Richland County (Sidney) grew from 10,504 to 10,716 people (a 0.1 percent annual growth rate).

Over the last 30 years, the greatest rates of population decrease in the lower Missouri River basin (Figure 4-12) have been in the Little Missouri River subbasin, which decreased from 8,188 people to 5,797 (1.1 percent annual loss rate); the Sheridan County Groundwater Area, which declined from 6,548 to 4,732 (1.0 percent annual loss rate); and the lower Missouri River subbasin which declined from 46,391 to 34,496 (1.0 percent annual loss rate).

**Figure 4-12. Population trends in Lower Missouri River Basin counties**



Source: Bureau of Census and NPA DATA, Inc.

The largest communities in the 13 counties are Havre (population 10,201) and Glasgow (3,572). Smaller towns include Wolf Point (2,880), Malta (2,340), Plentywood (2,136), Chinook (1,512), Scobey (1,154), Harlem (882), Poplar (881), Circle (805), Culbertson (796), and Wibaux (628). Of these 12 communities, only Malta and Plentywood have larger populations now than in 1960.

### LAND USE PLANNING

The types and extent of land use planning varies widely among jurisdictions and areas. Federal land use plans include Bureau of Land Management Resource Management Plans, U.S. Fish and Wildlife Service Refuge Management Plans, and the Custer National Forest Land and Resource Management Plan. Similarly, the Montana Department of State Lands has classified statehood grant land into land use categories, such as grazing, agriculture, or timber. Eight of the lower Missouri River basin's 13 counties have adopted a comprehensive county land use plan (Montana Department of Commerce 1989). All four Indian Reservations—Fort Belknap, Fort Peck, Blackfeet, and Rocky Boy's—have a current comprehensive reservation land use plan.

Other areas are managed for specific designated uses. Congressionally designated areas include eight national wildlife refuges—Black Coulee, Bowdoin, Lame Steer, Creedman Coulee, Hewitt Lake, Charles M. Russell, Lake Thibadeau, and Medicine Lake—and one wilderness area—Medicine Lake (see Map 4-4).

### CROPLAND PROGRAMS

Four major long-term government cropland programs have affected agriculture patterns in the basin. The first of these was the Agriculture Adjustment Program of the 1930s, followed by the Pick-Sloan Act of the 1940s, the Soil Bank of the 1950s, and the Conservation Reserve Program (CRP) of the 1980s and 1990s (Newman 1988). The Agriculture Adjustment, Soil Bank, and CRP programs sought to retire excess or erosive cropland, while the Pick-Sloan Act sought to provide low cost irrigation water and flood control. Virtually all of the cropland retired under CRP has been revegetated, usually to grass (Newman 1988).

One-half of Montana's cropland is eligible for retirement payments under CRP (8 million eligible acres). By 1992, approximately 2.9 million acres had been contracted for long-term cropland retirement (Gooby 1992). Four basin counties—Phillips, Daniels, Sheridan, and Valley—have reached the enrollment cap of 25 percent of county cropland in CRP contracts.

### LAND OWNERSHIP AND CROPLAND

The 13 counties of the lower Missouri River basin (see Map 4-5) comprise 22.5 million acres (Table 4-10). Privately owned land makes up about 70 percent of the land area, ranging from 91 percent in Sheridan County to 64 percent in the Milk River subbasin.

State-owned land averages about 6 percent of each subbasin land area, reflecting the pattern of two state sections per township. State land is managed primarily to generate revenue for school funding. Federal and tribal land makes up less than one-quarter of the basin, ranging from 30 percent in the Milk River subbasin to 5 percent in the Sheridan County Groundwater Area.

**Table 4-10. Lower Missouri River basin land ownership**

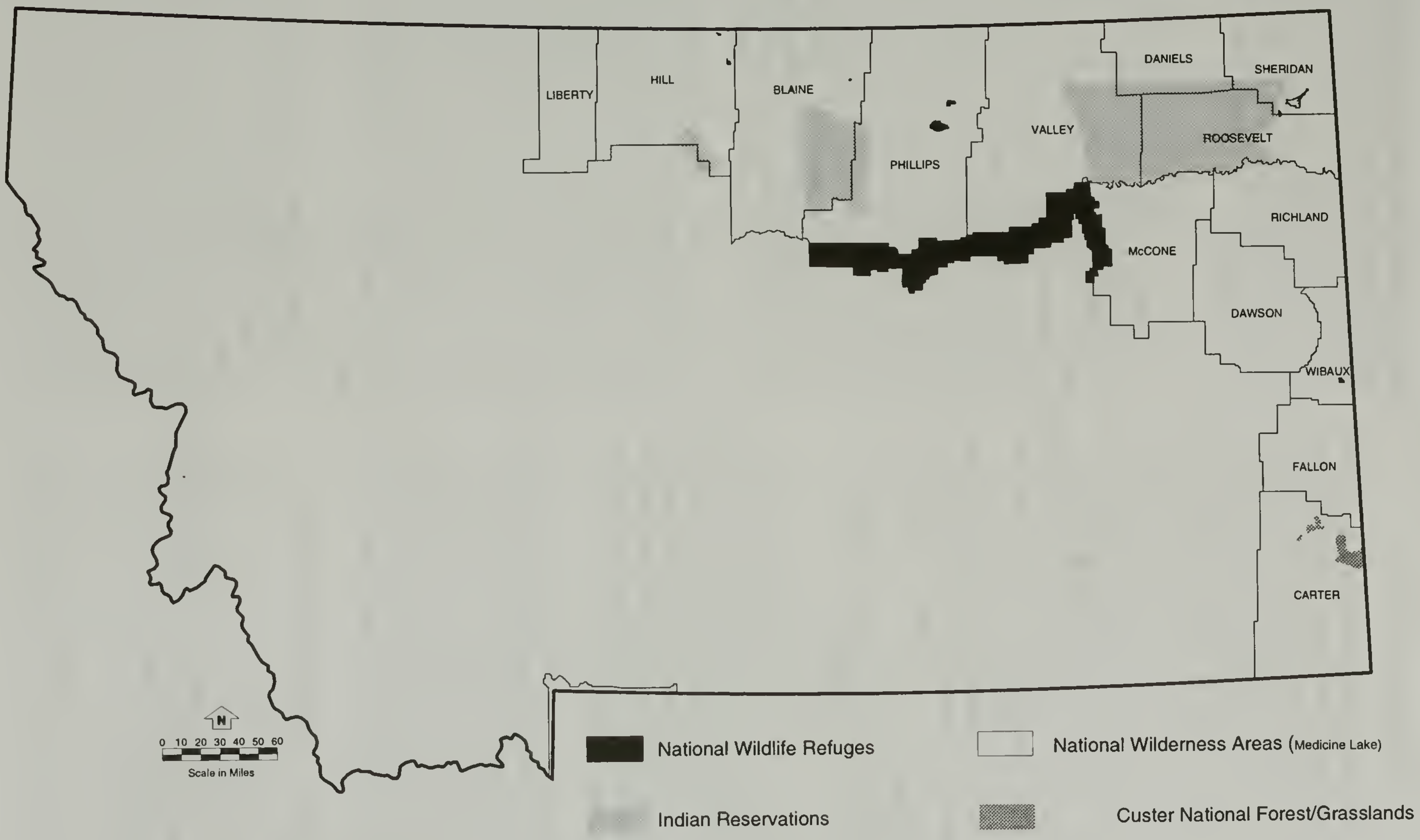
| | Acres of Land[a] | | | | |
|---|---|---|---|---|---|
| Ownership type | Lower Missouri Subbasin[b] | Milk River Subbasin[b] | Little Missouri Subbasin | Sheridan County Groundwater Area | Lower Missouri River Basin totals[b] |
| Private | 5,818,847 | 7,745,995 | 2,735,909 | 985,769 | 15,610,871 |
| State | 657,389 | 813,683 | 246,973 | 45,847 | 1,555,524 |
| Federal and Tribal | 2,228,084 | 3,602,562 | 751,518 | 56,384 | 5,278,085 |

[a] Includes all land within the 13 counties identified in Map 4.

[b] Land in Valley County is included in both the Milk River and the lower Missouri River subbasins, but is included once in the totals.

SOURCE: Montana Department of Commerce 1985

Map 4-4. Designated lands in the Lower Missouri River basin



### LAND USE ACTIVITIES

Lower Missouri River basin land use has followed regional trends. Land used for crops includes nonirrigated cropland and CRP (36 percent of the basin), irrigated cropland (1.6 percent of the basin, Map 4-5), and other long-term idle cropland (3.5 percent). Altogether, about 41 percent of the drainage is cropland. Irrigated cropland acreages have remained relatively constant over the past 30 years. Approximately 4 percent of the basin is in wildlife and forest uses, mostly in Phillips and Valley counties. About one-half of the lower Missouri River basin is in rangeland and grassland pasture uses. Approximately 0.3 percent of the basin is developed for urban or rural residences, or commercial use. Less than 1 percent of the basin is in other uses, such as transportation or utilities corridors, or unused areas such as bare rock. Appendix G lists the agricultural uses of land where reservations are proposed for irrigation projects.

## FISHERIES AND AQUATIC HABITAT

Streams and rivers in the lower Missouri River basin support a diverse fish population. Of the 80 species of fish found in Montana, 55 are found in the Missouri River Basin below Fort Peck Dam. Most of these are warm water species, but several species of trout are found in headwater tributaries to the Milk River and the cold water stretch of the Missouri River immediately below Fort Peck Dam.

Information in the following sections comes primarily from the Montana Rivers Information System database. Fisheries value class ratings, species composition, and relative abundance of fish were obtained from this source. DFWP's reservation application (DFWP 1991) was used to determine habitat conditions and additional information on species composition. Other information sources are cited in the text.

### THREATENED AND ENDANGERED SPECIES

Under the authority of the Endangered Species Act, USFWS listed the pallid sturgeon as an endangered species effective October 9, 1990. The pallid sturgeon is found in the Missouri River downstream from Fort Peck Dam.

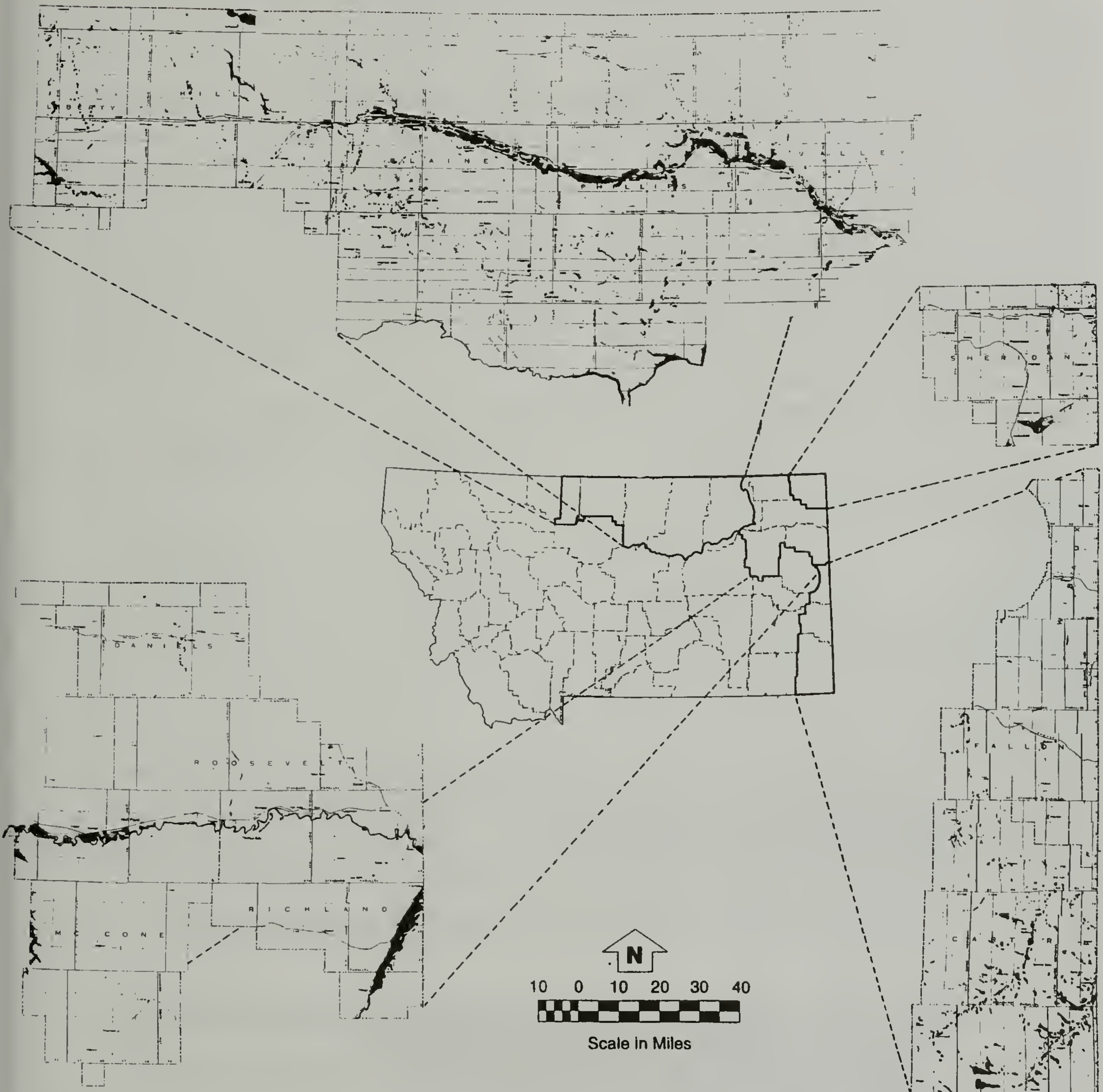
Regulations implementing the Endangered Species Act mandate that a decision to list a species is based solely on scientific information without reference to possible economic or other impacts of such determination. The act prohibits agencies and individuals from actions harmful to an endangered species. Prohibited activities include actions that may kill or injure individuals of a listed species by altering or degrading habitat or by impairing patterns of feeding or breeding.

USFWS has prepared a pallid sturgeon recovery plan which went into effect in November 1993. The recovery plan (USFWS 1993) contains recommendations for federal and state agencies to assist in the recovery of the pallid sturgeon. Among the many recommendations are that free movement of pallid sturgeon be restored at Fort Peck Dam, that Missouri River main-stem and tributary dams be operated to emulate predam flow patterns, that dynamic equilibrium of sediment transport in the Missouri River be restored, that new irrigation intakes be fitted with a 1/4-inch screen and have an intake velocity of 1/2 foot per second or less, or that intakes be located at a depth of at least 15 feet. The recovery plan also calls for protecting important habitat areas. This could include protecting water rights through acquisition, or formal agreements to ensure legal protection of instream flows within important habitats.

When a recovery plan is implemented, all federal agencies must use their authority to carry it out. Federal agencies must consult with USFWS to ensure that any action they authorize, fund, or carry out is not likely to harm an endangered species or designated critical habitat. Such actions could include changing dam operations, issuing permits that would allow an irrigation project to proceed, hydropower licensing, and federal funding or permitting of irrigation projects. USFWS can prohibit a federal action or propose an alternative course of action that would mitigate the impact to an endangered species or its critical habitat. Federal agencies can apply for an exemption to the requirements of the Endangered Species Act.

**Pallid Sturgeon:** The pallid sturgeon is a boneless fish that can exceed 5 feet in length and weigh more than 60 pounds (Figure 4-13). The original distribution of the pallid sturgeon included the Mississippi River and large tributaries from Iowa to Louisiana, the Missouri River from Great Falls to the mouth, and the Yellowstone River below the mouth of the Tongue River (Gilbraith et al. 1988). Channelization and damming of some of these rivers have greatly reduced the migratory range of this fish. Overfishing, damming of the rivers, hybridization

**Map 4-5. Irrigated land in the Lower Missouri River Basin**



with the shovelnose sturgeon, and lack of reproduction are thought to have led to the decline of this species. The Missouri and lower Yellowstone rivers are among the few places where pallid sturgeon survive today.

Little is known about the biology and habitat requirements of this fish. The pallid sturgeon is believed to spawn in flowing water in the spring, though it is not known whether it spawns every year. Sturgeon are reported to prefer habitat with flowing water over sand flats and gravel bars where they can eat aquatic insect larvae, mollusks, and small fish (Keenlyne 1989).

## SPECIES OF SPECIAL CONCERN

The Montana Natural Heritage Program (MNHP) maintains an inventory of species that are rare, threatened, endangered, or in need of further study to determine their status. Table 4-11 lists the fish that MNHP has identified as species of special concern in the Missouri River Basin below Fort Peck Dam. Designation of special concern does not necessarily give legal protection to these fish, but does indicate their rarity.

**Paddlefish:** The paddlefish is another boneless fish native to the Missouri and Yellowstone rivers in Montana (Figure 4-14). The largest paddlefish on record in Montana weighed 142.5 pounds (DFWP 1991), although they average 20 pounds and 50 inches in length (Brown 1971). During spring runoff, paddlefish migrate from Lake Sakakawea in North Dakota up the Missouri and Milk rivers. A portion of this population migrates up the Yellowstone River (Holton 1986). Spawning has been documented in the lower reach of the Milk River and concentrations of paddlefish have been observed near the confluence of the Milk and Missouri rivers (Holton 1986; Gardner and Stewart 1987). The combination of high, relatively warm turbid water from the Milk River and high flows in the Missouri River are thought to be important in initiating paddlefish migration and

**Table 4-11. Fish species of special concern in the Missouri River Basin below Fort Peck Dam**

| Species | MNHP state rank[a] | MNHP global rank[b] | USFWS status[c] |
|---|---|---|---|
| Pallid sturgeon | S1 | G1 | LE |
| Paddlefish | S3 | G4 | C2 |
| Shortnose gar | S1 | G5 | NS |
| Blue sucker | S3? | G4 | C2 |
| Sturgeon chub | S3 | G3 | C2 |
| Sicklefin chub | S1 | G2 | C2 |
| Northern redbelly- finescale dace | S3 | G4 | NS |
| Pearl dace | S2 | G5 | NS |

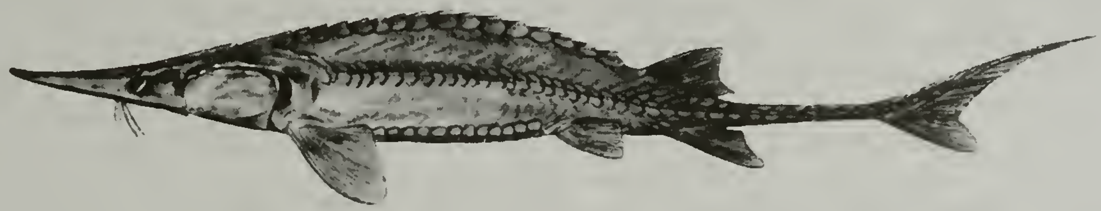
Rank
Global[b] & State[a]

| | | |
|---|---|---|
| G1 | S1 | Critically imperiled because of extreme rarity (5 or fewer occurrences, or very few remaining individuals), or because of some factor of its biology making it especially vulnerable to extinction. |
| G2 | S2 | Imperiled because of rarity (6 to 20 occurrences), or because of other factors demonstrably making it very vulnerable to extinction throughout its range. |
| G3 | S3 | Either very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factors; in the range of 21 to100 occurrences. |
| G4 | S4 | Apparently secure, though it may be quite rare in parts of its range, especially at the periphery. |
| G5 | S5 | Demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery. |

[c] LT = listed threatened
LE = listed endangered
CI = Notice of Review, Category 1 (substantial biological information on file to support the appropriateness of proposing to list as endangered or threatened).
C2 = Notice of Review, Category 2 (current information indicates that proposing to list as endangered or threatened is possibly appropriate, but substantial biological information is not on file to support an immediate ruling).
NS = No status assigned

SOURCE: MNHP 1993

**Figure 4-13. Pallid Sturgeon *(Scaphirhynchus albus)***



Source: Brown 1971. Reprinted with permission from the Montana State University Foundation.

spawning (Gardner and Stewart 1987). Paddlefish congregate in the dredge cuts below Fort Peck Dam in the summer and some remain there year-round.

Though paddlefish feed only on microorganisms, they can be caught by snagging and are valued for their flesh and caviar. Processed paddlefish caviar can be sold commercially for $300 to $500 a pound (Federal Register 1990).

Paddlefish populations in Montana appear stable (Peterman 1990), but populations in other states have suffered from overfishing, alteration of stream channels, and dams that block spawning migration.

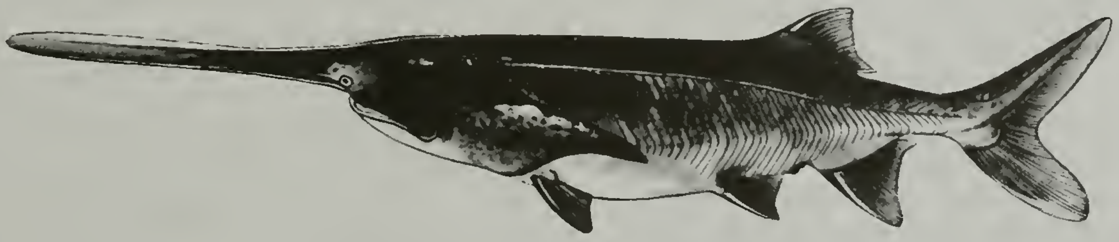
**Shortnose Gar:** Shortnose gar are native to Montana and are found in large rivers, backwaters, and reservoirs (Brown 1971). Shortnose gar are widely distributed throughout the Missouri and Mississippi drainages, with rivers in Montana at the fringe of this range. A few shortnose gar are caught each year in the dredge cuts below Fort Peck Dam and one was caught in the Missouri River (Holton 1986). DFWP (1991) reports that shortnose gar also have been found in the Milk River. Shortnose gar mainly eat fish. They spawn in shallow water with dense aquatic vegetation during May or June. Their bright green eggs are poisonous to humans, and gar are not considered game fish.

**Sturgeon Chub:** The sturgeon chub is a member of the minnow family and is not a game fish. This fish lives in medium to large rivers that are turbid and warm, in areas of strong current with a sand or gravel bottom (Lee et al. 1980). It may be present in Box Elder Creek (USFWS 1993). The sturgeon chub also was reported in the Milk River drainage during the railroad surveys of 1853-55 but has not been found there recently (Brown 1971). It grows to be about 4 inches long. Brown (1971) notes, "This minnow is uncommon to rare in Montana and has no special value except as an interesting native species." The sturgeon chub has been given a C2 status by USFWS, meaning that proposing to list this species as threatened or endangered is possibly appropriate, but there is not enough information to make an immediate ruling.

**Sicklefin Chub:** MNHP (1993) notes that the sicklefin chub is critically imperiled in Montana and imperiled throughout the rest of its range because of rarity or other factors. The sicklefin chub is a member of the minnow family and may grow to 3.5 inches. It has been found in the Missouri below its confluence with the Milk River. Like the sturgeon chub, the sickelfin chub has been given a C2 status by USFWS.

**Northern Redbelly-Finescale Dace Hybrids:** Northern redbelly dace sometimes interbreed with finescale dace to produce a hybrid fish. All offspring

**Figure 4-14. Paddlefish *(Polyodon spathula)***



Source: Brown 1971. Reprinted with permission from the Montana State University Foundation.

of this cross are females and are genetically identical to their mothers. These hybrids have been found in several locations in the Missouri River Basin below Fort Peck Dam including Redwater River, four streams on the Fort Peck Indian Reservation, Hawk Creek northwest of Glasgow, and Little Boxelder Creek.

**Pearl Dace:** The pearl dace is a member of the minnow family, native to Montana, and occasionally found in small cold streams north of the Missouri River. MNHP (1992) notes the pearl dace is imperiled because of rarity in Montana, though it is secure globally. It feeds on aquatic organisms such as insects, crustaceans, and worms (Brown 1971). Pearl dace grow to a length of 3 to 4 inches. They are found on the east and middle forks of the Poplar River and the Poplar River main stem.

**Blue Sucker:** Though apparently secure globally, the blue sucker is found locally within its restricted range in Montana. It has been found in the lower Missouri River, the Marias and Teton rivers, the lower Judith River, near the mouth of the Musselshell River, the lower portion of the Yellowstone River, and possibly the Milk River (Hunter 1991; USFWS 1993). Specimens weighing 16 pounds have been reported elsewhere, but most in Montana weigh less than 7.7 pounds (Brown 1971). The largest in Montana weighed about 11 1/2 pounds (Hunter 1991). The blue sucker is not a game fish in Montana, though it is said to be highly prized as a food fish in other areas (Brown 1971).

## LOWER MISSOURI RIVER SUBBASIN

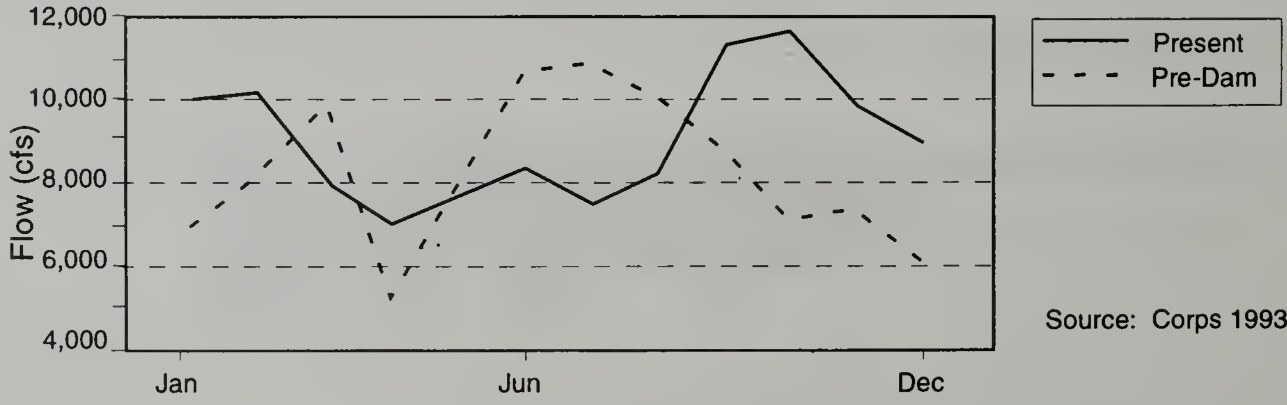
**Missouri River Drainage:** Most water requests for consumptive and instream reservations in the lower Missouri River subbasin would take water from the main stem of the Missouri River. The portion of the Missouri River from Fort Peck Dam to North Dakota supports one of the most diverse fish populations in the state of Montana, including five species of special concern. These are the pallid sturgeon, an endangered species; paddlefish; shortnose gar; sicklefin chub; and blue sucker. The Missouri River also supports a wide variety of game fish, including shovelnose sturgeon, walleye, sauger, northern pike, and a host of forage fish (Appendix H). DFWP rates this portion of the river as a Class I stream with outstanding fishery values.

Fort Peck Dam altered the aquatic habitat of the Missouri River in several ways. It created an obstruction to migrating paddlefish and pallid sturgeon, and altered the flow pattern of the river such that peak flows now occur in the fall rather than the spring and early summer (Figure 4-15). Water released from the reservoir during the spring and summer typically is colder than natural flows and the natural pattern of erosion and sediment deposition in the river channel is disrupted. Lower, colder and less turbid spring flows are thought to reduce the stimulus that triggers paddlefish migration. Consequently, flows from the Milk River, which are warmer and more turbid, are thought important to initiate paddlefish migration in the Missouri River.

Water released from the reservoir contains much less sediment than before the dam was constructed. With its capacity to carry more sediment, the river is cutting downward and laterally into the river banks. The resulting stream channel may become wider and shallower and contain fewer point bars and islands.

While Fort Peck Dam appears to block migration of both paddlefish and pallid sturgeon, the dredge cuts below the dam seem to provide suitable habitat for paddlefish, which congregate there during the

**Figure 4-15. Present and pre-dam flows below Fort Peck Dam**



Source: Corps 1993

summer. The portion of the river just downstream from Fort Peck also is noted for its trophy rainbow trout fishery, which is attributed to clear, cold water releases from the reservoir. Below the dam, the Missouri River regains some of its character as a prairie stream after the Milk and Poplar rivers add warmer and more turbid water.

**Poplar River Drainage:** The forks of the Poplar River and the main-stem Poplar River upstream from the Fort Peck Indian Reservation support a warm water fishery. Northern pike and walleye are the principal game fish in the east, middle, and west forks of the Poplar River, while walleye, northern pike, sauger, and smallmouth bass are found in the Poplar River. A wide variety of forage fish also is found in these streams as shown in Appendix H.

Habitat on these streams consists of long pools with little or no measurable current for much of the year, separated by short riffles. Low flows during the winter coupled with severe cold and depressed levels of dissolved oxygen are thought to be the causes of fish kills during the winters of 1977-78 and 1978-79 when kills of walleye and northern pike were reported.

**Redwater River:** Like the Poplar River, the Redwater River supports a warm water fishery in long pools separated by short riffles. Game fish include walleye, northern pike, sauger, channel catfish, and burbot in the lower 30 miles of river and northern pike in the reach between Circle and the confluence with the East Fork. Both these reaches support a rich diversity of nongame fish despite periods of low flow, low levels of dissolved oxygen, and elevated temperatures; 20 species occur in the lower reach and 21 in the upper.

### MILK RIVER SUBBASIN

Reservations for consumptive use, instream use, or both have been requested on 13 streams in the Milk River drainage. Beaver (Hill County), Little Boxelder, Clear, and the upper portions of Peoples and Beaver (Phillips County) creeks support locally important populations of trout. Warm water game fish such as northern pike, sauger, walleye, and smallmouth bass are found in Battle, lower Beaver (Phillips County), and Rock creeks, and Milk and Frenchman rivers. As indicated in Appendix H, these streams support a diverse population of nongame species such as minnows, suckers, and catfish.

The Hill County Water District has requested a reservation from the lower portion of the Marias River, which supports a warm water fishery (see DNRC 1991 for a discussion of the fishery of the Marias River). While the diversion for this project is in the Marias River drainage, most land in the water district lies in the Milk River drainage.

Game fish from the Milk River use some of the tributaries for spawning as shown in Table 4-12. Many forage fish produced in these streams also find their way to the Milk River. The lower portion of the Milk River provides spawning and rearing habitat for fish from the Missouri River.

**Table 4-12. Tributaries providing spawning habitat for game fish inhabiting the Milk River**

| Tributary stream | Game fish species |
|---|---|
| Battle Creek | walleye |
| Beaver Creek (Phillips County) | walleye, northern pike |
| Frenchman River | northern pike, smallmouth bass |
| Rock Creek | walleye, northern pike, smallmouth bass |

Habitat in the Milk River has been affected by seven dams, extensive diversion of water for irrigation, and degradation of water quality due to municipal discharges and irrigation return flows. Battle and Peoples creeks occasionally suffer from extremely low summer flows.

### LITTLE MISSOURI RIVER SUBBASIN

**Little Missouri River:** The Little Missouri River is a prairie stream that supports a warm water fishery. Sauger and channel catfish are the only game fish present, but 15 nongame species also are found there (see Appendix H). Habitat is characterized by high flow during spring runoff, which approaches zero by summer's end leaving deep pools separated by short, shallow riffles.

Besides spawning in the river, fish from the Little Missouri River depend on several tributaries for spawning and rearing habitat. It is believed that Boxelder and Little Beaver creeks both provide spawning and rearing areas for channel catfish, and sauger from the Little Missouri River are thought to spawn in Boxelder Creek.

**Little Beaver Creek:** Twenty-two warm water fish species are found in Little Beaver Creek, including northern pike and channel catfish. Northern pike, ranging in size from young of the year to 9 pounds, inhabit pools that have little or no flowing water in the summer. Young pike use the shallower pools and the edges of pools with emerging vegetation during the summer, while larger adults are found in deeper areas. Channel catfish are reported to use the lower portion of Little Beaver Creek.

**Boxelder Creek:** Boxelder Creek supports 20 warm water fish species, including channel catfish, a few northern pike, and migratory sauger. Although this intermittent stream supports game fish in large, deep pools, game fish numbers probably are limited by intermittent streamflows, lack of spawning habitat, poor water quality, and elevated stream temperatures.

**Beaver Creek:** Walleye and northern pike are found in larger isolated pools of Beaver Creek. Specimens weighing nearly 11 pounds have been caught. Twenty-five other fish species also are found in the creek (Guzevich 1993). Fathead minnows are the most abundant forage fish. Fish numbers probably are limited by intermittent streamflow and lack of spawning habitat.

#### SHERIDAN COUNTY GROUNDWATER AREA

Most of the projects proposed by the Sheridan County Conservation District would divert groundwater. Groundwater and surface water in this area is directly connected in some cases, so the proposed projects could affect area lakes. Medicine Lake has supported populations of northern pike, but recent harsh winters and low water levels have resulted in fish kills. Gaffney Lake and Lake #12 on the Medicine Lake National Wildlife Refuge do not support fishing due to winter kills (DFWP 1989). Brush Lake does not support game fish (DFWP 1989). Most of the lakes in this area are too salty to support game fish.

Proposed groundwater reservations also could affect Big Muddy Creek. Big Muddy Creek supports a variety of forage fish and a few northern pike, walleye, sauger, and channel catfish.

## WILDLIFE

### THREATENED AND ENDANGERED SPECIES

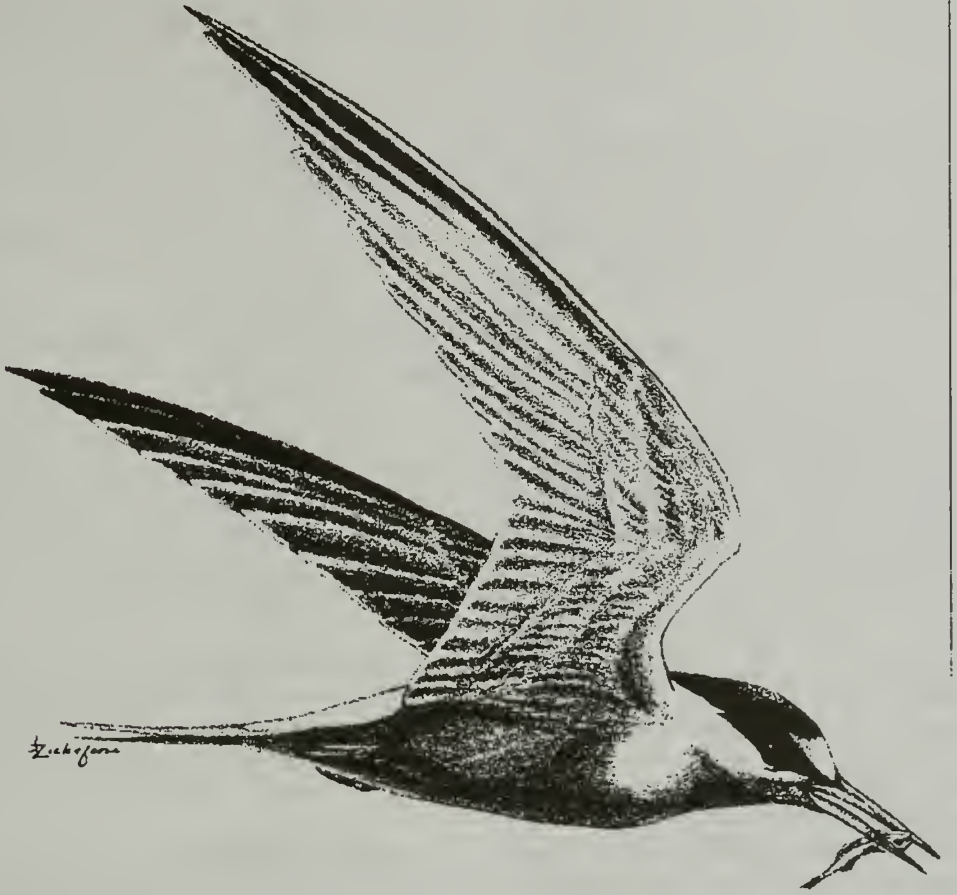
Eight wildlife species listed by USFWS as threatened or endangered have been recorded within the study area: least tern, piping plover, bald eagle, whooping crane, peregrine falcon, gray wolf, grizzly bear, and black-footed ferret. The last confirmed black-footed ferret sighting in Montana was near Ekalaka in 1977. Reintroduction efforts are focusing on Phillips County. The gray wolf and grizzly bear are no longer present in drainages where reservations are requested.

**Least Tern:** Populations of least terns are found on the east and west coasts and in the interior of the United States. The interior and west coast populations of least tern (Figure 4-16) are listed as endangered species by USFWS. The least tern nests in areas that are generally free of vegetation on open beaches, sandbars in rivers, and disturbed areas such as gravel pits (USFWS 1990). It nests in colonies of 2 to 25 individuals. Diet of the interior least tern consists of small fish and a few crustaceans, which are gathered in shallow areas of lakes, streams, and rivers by skimming the water surface or by hovering and diving.

The interior least tern is migratory. During the summer breeding season, this tern population is distributed in Montana along the Missouri River and its tributaries. Breeding least terns have been found on Fort Peck Reservoir, along the Missouri River in Richland and McCone counties, and along the lower Yellowstone River in Prairie County. Since 1940, least tern populations have decreased nationwide by about 50 percent (Aderhold 1988). In 1990, there were about 5,000 least terns in the interior population, with about 110 individuals observed in Montana. Twenty-four nests were found in Montana in 1992 (Montana Piping Plover Recovery Committee 1993). USFWS would consider delisting the tern if, among other things, essential habitat were protected and nationwide populations were to increase to 7,000 birds, including 50 in Montana.

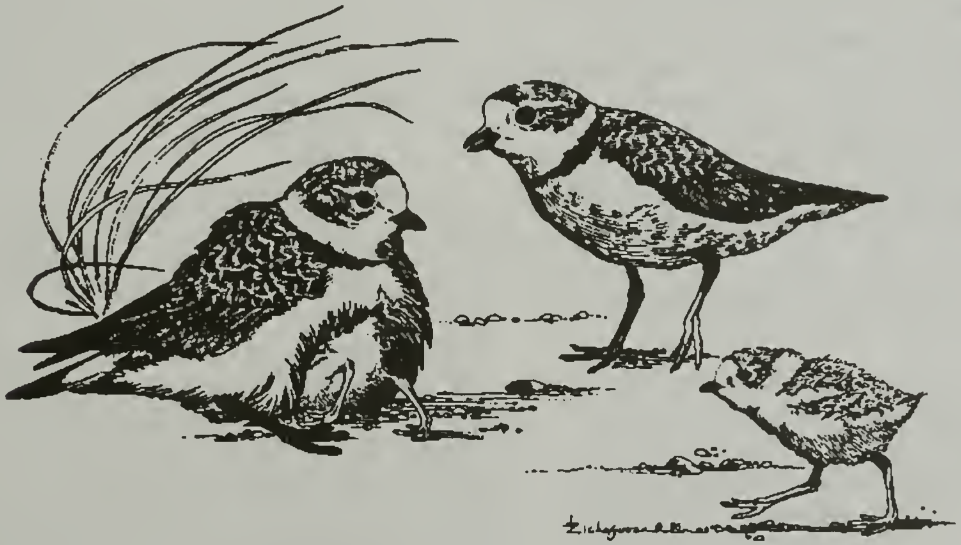
**Piping Plover:** The piping plover (Figure 4-17) is a migratory species that breeds along prairie rivers and saline wetlands in the Great Plains, on sandy beaches of the Great Lakes, and along the Atlantic coast (USFWS 1988). Populations in the Great Lakes region are listed by USFWS as endangered under the Endangered Species Act, while the other populations are listed as threatened. In Montana, piping plovers have been found nesting along Fort Peck Reservoir, at saline wetlands in Sheridan County between Westby and Medicine Lake National Wildlife Refuge (USFWS 1988), and on islands in the Missouri River below Fort Peck Reservoir. Nests in Montana are typically found on poorly vegetated dry salt flats or sandy/gravelly beaches. These plovers appear to feed on insects and other invertebrates along the beaches or salt flats.

**Figure 4-16. Least Tern in flight**



Source: USFWS 1991

**Figure 4-17. Piping Plover with young**



Source: USFWS 1988

In order for the piping plover to be removed from the threatened species list, the number of birds in the northern Great Plains of the U.S. would have to reach 1,300 pairs, with another 2,500 in Canada. If the population in Montana could be stabilized with at least 60 pairs for 15 years, delisting could be considered for Montana alone. During 1992, the 290 adults in Montana accounted for roughly 17 percent of the northern Great Plains/prairie population of 1,719 in the United States (Montana Piping Plover Recovery Committee 1993). Since 1987, the total number of breeding pairs in the U.S. and Canada combined has varied between 1,979 and 2,340.

**Bald Eagle:** The bald eagle in the lower 48 states has been listed as endangered species since 1978. Bald eagles winter on the Missouri River below Fort Peck Dam where open water, an abundance of waterfowl, and the discharge of dead fish through the turbines provide suitable habitat and food (DFWP 1991). There are no recent records of nesting bald eagles on streams where reservations are requested.

**Whooping Crane:** The whooping crane is an endangered species that migrates through Montana. It is the largest wading bird in the U.S., standing nearly 5 feet tall with a wing span about 7 feet. Most of birds migrating through the study area have been reported from Sheridan County near Medicine Lake National Wildlife Refuge. These birds are thought to be part of a group that nests in the northern part of Canada's Wood Buffalo National Park and winters along the Gulf of Mexico in Aransas National Wildlife Refuge in Texas. The only other group is found at Grays Lake National Wildlife refuge in Idaho (Aderhold 1988).

**Peregrine Falcon:** The peregrine falcon has been listed as an endangered species since 1972. The effects of pesticides on reproduction are among the factors that led to the decline of the peregrine. It migrates through Montana but no longer nests in the area where reservations are sought. Reintroduction efforts have focused on southwestern Montana. Diet of the peregrine falcon consists exclusively of other birds (Aderhold 1988).

## SPECIES OF SPECIAL CONCERN

DFWP has identified vertebrate species of special concern (Flath 1984) that are known or suspected to live in the lower Missouri River vicinity. These species include animals listed under the Federal Endangered Species Act of 1973, as amended, and other species designated as rare, in need of additional research, or requiring special management. Table 4-13 lists sensitive species, their status, and possible presence within the Missouri River basin. Of the wildlife species of special concern identified in the lower Missouri River basin, those listed in Table 4-14 would be expected to live in riparian areas or on upland grasslands and sagebrush grasslands that could be affected by irrigation development.

### LOWER MISSOURI RIVER SUBBASIN

**Missouri River:** The riparian forest along the lower Missouri River is one of the most important wildlife habitats in the area. The riparian habitat supports both mule and white-tailed deer, pheasants, sharp-tailed grouse, and mourning doves. Merriam's wild turkeys have recently been introduced in the reach between Fort Peck and the confluence of the Milk River. Mink, beaver, muskrat, and raccoon are the chief furbearers depending on the river and riparian habitat.

Migratory waterfowl use the river, and several duck species and Canada geese nest there. Both the endangered least tern and the threatened piping plover are known to nest on islands and sandbars along the river.

**Poplar River Drainage:** DeSimone (1979) studied wildlife in the Poplar River drainage. During his study, the upper reaches of the East Fork provided the best duck breeding habitat in the drainage. Nesting habitat for Canada geese was found along the upper portion of the West Fork. High fall use of the Middle Fork by ducks also was documented.

This drainage also provides habitat for white-tailed deer, a few antelope and mule deer, pheasants, Hungarian partridge, and sharp-tailed grouse. Beaver, mink, raccoon, and muskrat are the most common furbearers along rivers in this drainage, and coyotes also are common.

USFWS has proposed an international waterfowl production and wetland project on a tributary of the East Fork of the Poplar River. It would require diversion of spring flows to the wetland.

**Redwater River:** Habitat in the Redwater River drainage supports mule and white-tailed deer and antelope. While detailed data are lacking on waterfowl use, the river is thought to provide nesting habitat for Canada geese and several duck species (DFWP 1991). Migrating waterfowl use the river in spring and fall. Uplands bordering the valley support sharp-tailed grouse. Habitat is limited for sage grouse, Hungarian partridge, and pheasant.

**Table 4-13. Species of special concern known to occur in Missouri River subbasins[a]**

| Species | Status | Location in subbasin |
|---|---|---|
| Lynx | undetermined | Milk River |
| Blacktailed prairie dog | undetermined | Milk River, lower Missouri River, Little Missouri River |
| Meadow jumping mouse | undetermined | lower Missouri River, Little Missouri River |
| Preble shrew | undetermined | Milk River |
| Hispid pocket mouse | rare | Little Missouri River |
| Dwarf shrew | undetermined | Sheridan County |
| Merriam shrew | undetermined | Milk River, lower Missouri River, Little Missouri River |
| Keen's bat | undetermined | lower Missouri River |
| Townsend's big-eared bat | undetermined | lower Missouri River |
| Dakota toad | undetermined | Milk River, lower Missouri River, Sheridan County |
| Snapping turtle | undetermined | Milk River, lower Missouri River, Little Missouri River, Sheridan County |
| Spiny softshell turtle | undetermined | Milk River, lower Missouri River, Little Missouri River |
| Milk snake | rare | Milk River |
| Plains hognose snake | rare | Milk River, lower Missouri River, Little Missouri River, Sheridan County |
| Osprey | common | Milk River |
| Cooper's hawk | undetermined | Milk River, lower Missouri River, Little Missouri River, Sheridan County |
| Northern goshawk | undetermined | Milk River, Sheridan County |
| Ferruginous hawk | rare | Milk River, lower Missouri River, Little Missouri River, Sheridan County |
| Golden eagle | common | Milk River, lower Missouri River, Little Missouri River, Sheridan County |
| Merlin | undetermined | Milk River, lower Missouri River, Little Missouri River, Sheridan County |
| Prairie falcon | undetermined | Milk River, lower Missouri River, Little Missouri River, Sheridan County |
| Upland sandpiper | undetermined | Milk River, lower Missouri River, Little Missouri River, Sheridan County |
| Long-billed curlew | undetermined | Milk River, lower Missouri River, Little Missouri River, Sheridan County |
| Burrowing owl | undetermined | Milk River, lower Missouri River, Little Missouri River, Sheridan County |
| Long-eared owl | undetermined | Milk River, lower Missouri River, Little Missouri River, Sheridan County |
| Mountain plover | rare | Milk River, lower Missouri River |
| Northern saw-whet owl | undetermined | Little Missouri River |
| Eastern bluebird | rare | lower Missouri River, Little Missouri River, Sheridan County |
| Dickcissel | rare | Milk River, lower Missouri River, Little Missouri River, Sheridan County |
| Clay-colored sparrow | undetermined | Milk, lower Missouri, Little Missouri, Sheridan County |
| Field sparrow | undetermined | Milk River, lower Missouri River, Little Missouri River, Sheridan County |
| Bobolink | undetermined | Milk River, lower Missouri River, Little Missouri River, Sheridan County |
| Brewer's sparrow | undetermined | lower Missouri River, Little Missouri River, Sheridan County |
| White-faced ibis | rare | lower Missouri River, Sheridan County |

[a] Does not include federally listed threatened or endangered species
SOURCE: Flath 1984

**Table 4-14. Sensitive species that might be found in vegetation communities likely to be affected by irrigation development projects**

| Species | Habitat |
|---|---|
| Blacktailed prairie dog | sagebrush-grasslands |
| Merriam shrew | sagebrush-grasslands |
| Osprey | riparian areas (nesting) |
| Bald eagle | riparian areas |
| Ferruginous hawk | sagebrush-grasslands (nesting) |
| Golden eagle | sagebrush-grasslands |
| Upland sandpiper | sagebrush-grasslands (nesting) |
| Long-billed curlew | sagebrush-grasslands (nesting) |
| Burrowing owl | sagebrush-grasslands (often nesting in association with prairie dogs) |
| Mountain plover | sagebrush-grasslands (nesting) |
| Bobolink | sagebrush-grasslands (nesting) |
| Brewer's sparrow | sagebrush-grasslands (nesting) |
| Least tern | riparian areas (nesting) |
| Piping plover | riparian areas (nesting) |

### MILK RIVER SUBBASIN

The riparian habitat of the Milk River drainage supports mule and white-tailed deer, pheasants, sharp-tailed grouse, and mourning doves. Elk are found in the headwaters of Beaver, Little Boxelder, and Clear creeks. Upland gamebirds include ringnecked pheasants, sage and sharp-tailed grouse, and Hungarian partridge. Furbearers, including mink, beaver, muskrat, and raccoon, depend on riparian habitat along the river and streams. Coyotes and red fox also can be found in the drainage. Badger have been reported in the Battle Creek drainage. Migratory waterfowl use the river and creeks, and Canada geese and several duck species nest in the drainage. Prairie dog towns are found throughout the Beaver Creek (Phillips County) drainage.

### LITTLE MISSOURI RIVER SUBBASIN

**Little Missouri River:** The riparian trees and shrubs along the Little Missouri River provide habitat for resident and migratory songbirds. Furbearers associated with the watercourse and its riparian habitat include beaver, mink, muskrat, and raccoon. Red fox and coyote also are found here. Migrating mourning doves and waterfowl use the river riparian area. Mule and white-tailed deer are found along the river and in surrounding hills.

**Box Elder, Little Beaver, and Beaver Creeks:** DFWP (1991) reports that Box Elder, Little Beaver, and Beaver creeks support a variety of amphibians, and the riparian zone supports mink, coyote, beaver, and muskrat. Canada geese and great blue heron are found along Box Elder and Beaver creeks. Each of these creeks supports a variety of shorebirds. Blue-winged teal and mallard ducks nest along Little Beaver Creek. Wild turkey, ringnecked pheasant, sage grouse, sharp-tailed grouse, and mourning doves are found in the area. Hungarian partridge are found in the Beaver and Little Beaver creek drainages. Big game species found in these drainages include antelope, white-tailed deer, and mule deer.

### SHERIDAN COUNTY GROUNDWATER AREA

Sheridan County contains an extensive system of prairie potholes, lakes, and other wetlands (Appendix F), which are extensively used by breeding and migrating shorebirds and other waterfowl. The threatened piping plover nests near some of the saline lakes in the groundwater area. During 1992, 80 percent of the 285 piping plovers in Montana were found in Sheridan County. Within this area, USFWS owns and manages Medicine Lake National Wildlife Refuge and numerous waterfowl production areas and holds many additional easements on wetlands (Map 4-6).

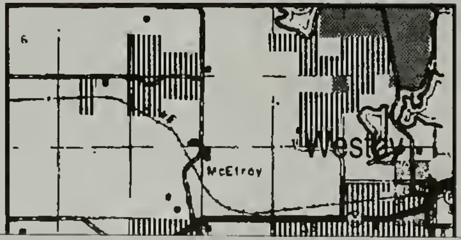
Several successive years of low snowfall and below normal rainfall have lowered the water table and many of the smaller wetlands were dry in the spring of 1993. Most of the larger lakes were far below their normal levels. Medicine Lake depends on groundwater and diversions from Big Muddy Creek to maintain its water level. In December 1992, it was about 5.6 feet (29,618 af) below its managed level (Gutzke 1993).

Nearly half of the proposed projects are located on land that is not currently cultivated. This land provides habitat for pheasants, white-tailed deer, and red fox. Most of this land appears to be in the Conservation Reserve Program.

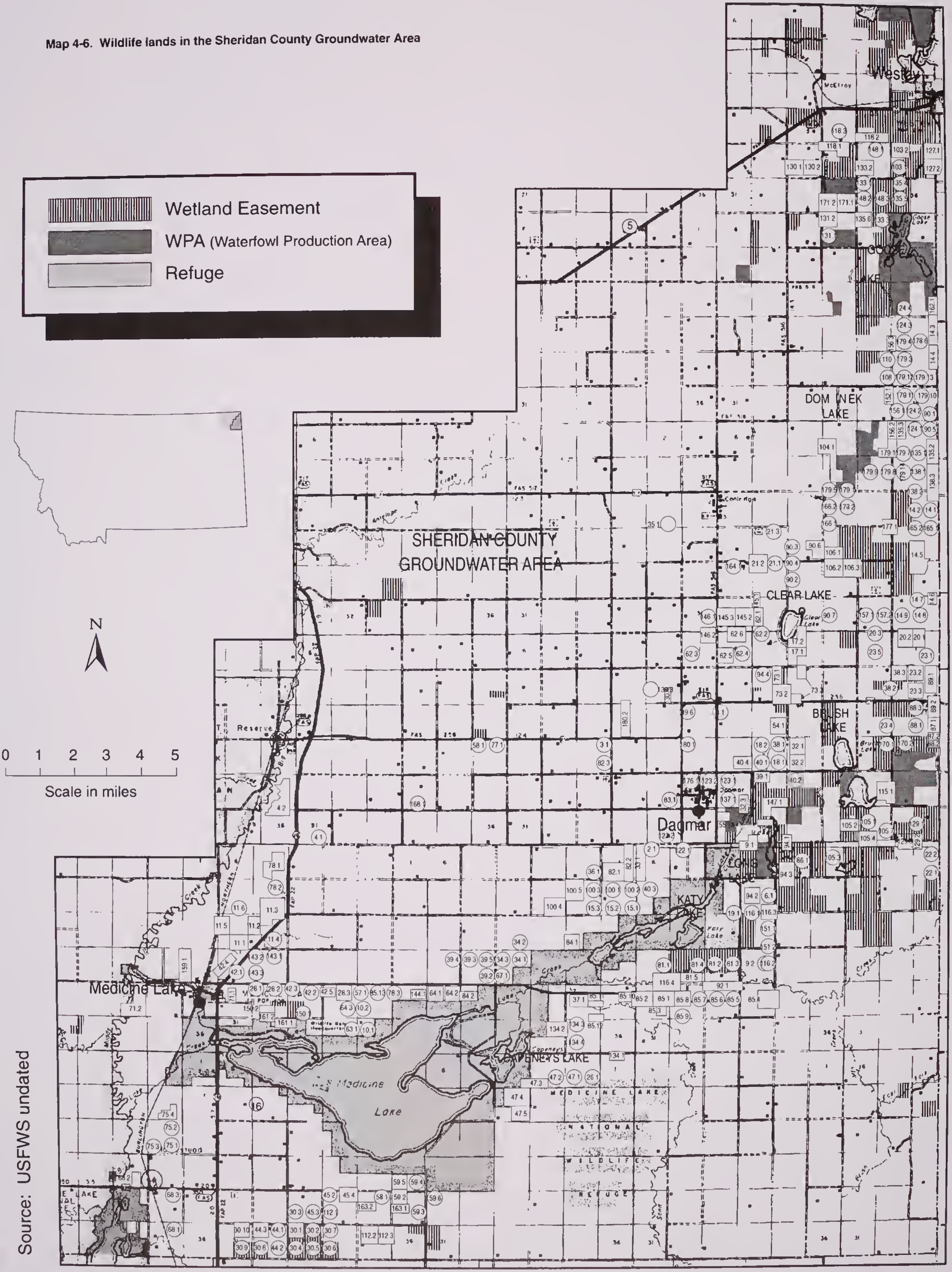
## HISTORICAL, ARCHAEOLOGICAL, AND PALEONTOLOGICAL RESOURCES

The proposed irrigation projects would be developed on the floodplains and terraces of the Missouri River and on benchlands above the Milk River, Poplar River, Little Missouri River, and tributaries. These landscapes have the potential to contain historical and prehistorical evidence of Montana's past. A wide variety of activities are known to have occurred in the study area, some of which are reflected in recorded sites identified through file searches conducted by

Map 4-6.  Wildlife lands in the Sheridan County Groundwater Area



Map 4-6. Wildlife lands in the Sheridan County Groundwater Area



Source: USFWS undated

the State Historic Preservation Office (SHPO) at DNRC's request. Table 4-15 lists sites that might be affected by irrigation projects. Many of the municipalities requesting water reservations contain historic sites listed on the National Register of Historic Places. The proposed reservations would not affect these sites.

There has been no systematic on-the-ground survey of historical and archaeological resources on land to be developed by the various irrigation and municipal projects. About two-thirds of these lands are cultivated at present, reducing the potential for discovery of intact cultural artifacts. Undisturbed range or pastureland is more likely to contain undiscovered cultural resource sites. A total of 158 sites are recorded on land adjacent to Fort Peck Reservoir. Some of these sites could be affected by changing water levels within the lake.

The lower Missouri River basin has outcrops of a number of geologic formations that produce fossils from the Cretaceous period. Table 4-16 lists the paleontological sensitivity of geologic formations present in the subbasins. Many fossils, including fossilized plants and marine invertebrates, are common and, with rare exceptions, have little scientific value. Fossilized reptiles, fish, dinosaurs, and mammals have more scientific value. The discovery of fossilized bone, or the rare complete skeleton, is considered to have moderate to high paleontological significance. Most Montana fossil finds of scientific significance have been in areas not suitable for the development of irrigation. For example, fossil finds often occur in badlands where topography or soil type limits agricultural activities, or in areas of rock outcrop such as cliffs. In contrast, the proposed irrigation projects are located on floodplains, terraces, and benchlands where geologic processes such as glaciation or other depositional environments limit the possibilities that important fossils would remain intact.

#### LOWER MISSOURI RIVER SUBBASIN

Based on activities known to have occurred in this subbasin, several areas are likely to yield additional archaeological or historical information. Areas with moderate potential for new archaeological site discovery are at the confluences of the Missouri River with its tributary streams such as Milk, Redwater, and Poplar rivers and Muddy Creek. These areas exhibit potential to yield new sites or additional information about the past use of these areas. The lower Missouri River subbasin also contains outcrops of the Hell Creek Formation, which may contain fossils. These outcrops are in areas along the West Fork of the Poplar River and Poplar River and near the Missouri River between Wolf Point and Poplar.

#### MILK RIVER SUBBASIN

A wide variety of historical activities is believed to have occurred in this subbasin. Few of these activities are reflected in the record of known sites, probably due to the lack of surveys conducted in the area. This basin contains some isolated outcropping of the Hell Creek Formation. This formation produces significant vertebrate fossils in other parts of Montana. The proposed irrigation projects in this subbasin are located away from these outcrop areas.

#### LITTLE MISSOURI RIVER SUBBASIN

Projects in the Little Missouri River subbasin would be developed on landscapes surrounding tributaries to the Little Missouri River. Many of the proposed reservations are for water-spreading projects located on flat to gently sloping land, with potential for new archaeological site discovery.

The Hell Creek Formation, known to produce fossils, is exposed in the Box Elder and Little Beaver creek drainages, although none of the proposed projects would affect known outcrops.

#### SHERIDAN COUNTY GROUNDWATER AREA

As noted in Table 4-15, many of the known sites in this subbasin are associated with the agricultural past of this area. About 81,560 acres (82 percent) of the land proposed for irrigation in this subbasin is under cultivation, limiting the potential for new site discovery.

## RECREATION

### PATTERNS OF RECREATION PARTICIPATION IN MONTANA

Results from two comprehensive studies show stability in the proportion of Montana residents participating in outdoor recreation between 1979 and 1985 (Wallwork et al. 1980; Frost and McCool 1986). A comparison of study results (McCool and Frost 1987) indicates that outdoor activities for adults changed little between these years (Table 4-17).

the State Historic Preservation Office (SHPO) at DNRC's request. Table 4-15 lists sites that might be affected by irrigation projects. Many of the municipalities requesting water reservations contain historic sites listed on the National Register of Historic Places. The proposed reservations would not affect these sites.

There has been no systematic on-the-ground survey of historical and archaeological resources on land to be developed by the various irrigation and municipal projects. About two-thirds of these lands are cultivated at present, reducing the potential for discovery of intact cultural artifacts. Undisturbed range or pastureland is more likely to contain undiscovered cultural resource sites. A total of 158 sites are recorded on land adjacent to Fort Peck Reservoir. Some of these sites could be affected by changing water levels within the lake.

The lower Missouri River basin has outcrops of a number of geologic formations that produce fossils from the Cretaceous period. Table 4-16 lists the paleontological sensitivity of geologic formations present in the subbasins. Many fossils, including fossilized plants and marine invertebrates, are common and, with rare exceptions, have little scientific value. Fossilized reptiles, fish, dinosaurs, and mammals have more scientific value. The discovery of fossilized bone, or the rare complete skeleton, is considered to have moderate to high paleontological significance. Most Montana fossil finds of scientific significance have been in areas not suitable for the development of irrigation. For example, fossil finds often occur in badlands where topography or soil type limits agricultural activities, or in areas of rock outcrop such as cliffs. In contrast, the proposed irrigation projects are located on floodplains, terraces, and benchlands where geologic processes such as glaciation or other depositional environments limit the possibilities that important fossils would remain intact.

### LOWER MISSOURI RIVER SUBBASIN

Based on activities known to have occurred in this subbasin, several areas are likely to yield additional archaeological or historical information. Areas with moderate potential for new archaeological site discovery are at the confluences of the Missouri River with its tributary streams such as Milk, Redwater, and Poplar rivers and Muddy Creek. These areas exhibit potential to yield new sites or additional information about the past use of these areas. The lower Missouri River subbasin also contains outcrops of the Hell Creek Formation, which may contain fossils. These outcrops are in areas along the West Fork of the Poplar River and Poplar River and near the Missouri River between Wolf Point and Poplar.

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The Hell Creek Formation, known to produce fossils, is exposed in the Box Elder and Little Beaver creek drainages, although none of the proposed projects would affect known outcrops.

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As noted in Table 4-15, many of the known sites in this subbasin are associated with the agricultural past of this area. About 81,560 acres (82 percent) of the land proposed for irrigation in this subbasin is under cultivation, limiting the potential for new site discovery.

# RECREATION

## PATTERNS OF RECREATION PARTICIPATION IN MONTANA

Results from two comprehensive studies show stability in the proportion of Montana residents participating in outdoor recreation between 1979 and 1985 (Wallwork et al. 1980; Frost and McCool 1986). A comparison of study results (McCool and Frost 1987) indicates that outdoor activities for adults changed little between these years (Table 4-17).

**Table 4-15. List of historical and archaeological sites potentially affected by the proposed conservation district water reservation projects**

| Site # | Site status[1] | Site type | Ownership |
|---|---|---|---|
| **Lower Missouri River Subbasin** | | | |
| 24VL0721 | unknown | lithic materials | DFWP |
| 24VL1171 | recorded/razed | historic "Red" Donovan house | USFWS |
| 24RL0084 | unknown | tipi ring, rock alignment, cairn | BLM |
| 24RL0066 | unknown | historic homestead remnant | private |
| 24RL0189 | ineligible | historic Rud homestead, outbuildings | private |
| 24RV0083 | unknown | lithic materials | BLM |
| 24RV0048 | ineligible | Rivermine coal mine | state |
| 24RV0049 | unknown | Woody Dugout coal mine | state |
| 24RL0507 | unknown | lithic chipping station, hearths | private |
| 24RV0201 | unknown | historic white site | ?? |
| 24RV0421 | unknown | tipi rings, lithic material, cairns | BLM |
| 24RV0413 | potentially eligible | tipi rings, lithics, cairn | private |
| 24RV0042 | ineligible | Old Government coal mine | private |
| 24RV1077 | unknown | lithic materials | private |
| 24RV0415 | unknown | Miller homestead | private |
| 24RV0414 | potentially eligible | Mitchell homestead | private |
| 24RV0419 | unknown | buried bone bed | private |
| 24RV0118 | ineligible | historic farmstead, dugouts | private |
| 24RV0119 | ineligible | historic farmstead, outbuildings | private |
| 24RV0120 | potentially eligible | historic Schultz homestead, outbuildings | private |
| 24RV0033 | ineligible | surface stone quarry | BLM |
| 24RV0445 | not eligible | Harder homestead remnants | private |
| 24RV0133 | potentially eligible | segments Great Northern railroad | private |
| 24RL0086 | eligible | historic Snowden and Nehi railroad bridges | private |
| 24DN0073 | unknown | wooden bridge | MDOT |
| 24MC0071 | unknown | buffalo pound, hearths (Nickles Kill), lithics | BLM |
| 24MC0070 | unknown | buffalo jump, camp (Twitchell Kill) | BLM |
| **Milk River Subbasin** | | | |
| 24VL1194 | ineligible | historic Vandalia canal system | multiple |
| DNRC-1 | unknown | tipi rings | private |
| **Little Missouri River Subbasin** | | | |
| 24CT0283 | ineligible | cabin, petroglyph | private |
| 24FA0226 | unknown | historic bridge | private |
| 24FA0030 | unknown | lithic materials | private |
| 24FA0081 | unknown | cairn | private |
| 24FA0264 | unknown | lithic materials | private |
| 24FA0265 | unknown | lithic materials | private |
| 24FA0248 | unknown | lithic materials | private |
| 24WX0072 | unknown | lithic materials | private |
| 24WX0052 | unknown | Albion Welsh homestead | private |
| 24WX0053 | unknown | historic homestead, private airport | private |
| 24WX0054 | unknown | Welsh farmstead | private |
| 24WX0091 | unknown | lithic material | private |
| 24WX0056 | unknown | wood frame granary | private |
| 24WX0070 | potentially eligible | lithic materials | private |
| 24WX0069 | unknown | lithic materials | private |
| **Sheridan County Groundwater Area** | | | |
| 24SH0794 | potentially eligible | Jasper Bedford house on Culbertson road | private |
| 24SH0001 | unknown | lithic material, tipi rings | USFWS |
| 24SH0002 | unknown | lithic material, tipi rings | USFWS |
| 24SH0789 | potentially eligible | historical farmstead | private |
| 24SH1008 | unknown | tipi rings | private |
| 24SH0049 | recorded/closed | Hancock coal mine | private |
| 24SH0686 | unknown | tipi rings, rock cairn, lithic materials | BIA |

| Site # | Site status[1] | Site type | Ownership |
|---|---|---|---|
| 24SH0051 | unknown | tipi rings, lithic materials | USFWS |
| 24SH0052 | unknown | tipi rings | USFWS |
| 24SH0796 | eligible | Axel Neilson homestead | private |
| 24SH0797 | potentially eligible | E.F. Madsen homestead | private |
| 24SH0160 | recorded/removed | historical farmstead, outbuildings | private |
| 24SH0653 | eligible | historical Volmer Lutheran church | private |
| 24SH0161 | recorded/removed | historical farmstead, outbuildings | private |
| 24SH0119 | unknown | wooden bridge | MDOT |
| 24SH0590 | unknown | lithic materials | private |
| 24SH0594 | unknown | lithic materials | private |
| 24SH0572 | unknown | lithic materials, occupation site | private |
| 24SH0720 | recommended eligible | historical Danish Brotherhood (DBS) Lodge #283 | private |
| 24SH0721 | eligible | historical farmstead, blacksmith shop | private |
| 24SH0042 | recorded/closed | Meyer coal mine | private |
| 24SH0592 | unknown | lithic materials | private |
| 24SH0591 | unknown | lithic materials | private |
| 24SH0600 | unknown | lithic materials | private |
| 24SH0718 | recommended eligible | historical Syverud homestead | private |
| 24SH0798 | potentially eligible | Andrew Dahl farmstead | private |
| 24SH0043 | recorded/closed | Lagerkvist-Anderson coal mines | private |

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[1] Site status indicates whether the site has potential for listing on the National Register of Historic Places.

**Table 4-16. Paleontological significance of major geologic formations in the study area**

| Formation | Depositional environment | Expected fossils | Probability of vertebrate fossil discovery | Paleontological importance |
|---|---|---|---|---|
| Quaternary alluvium | terrestrial | mammoth, horse, bison, camel | low | moderate |
| Flaxville (gravels) | terrestrial | none | very low | low |
| Fort Union | terrestrial | mammals, plants | low to moderate | moderate |
| Hell Creek | terrestrial | dinosaurs, mammals, plants | moderate | high |
| Fox Hills sandstone | marine shoreline | reptiles, fish | low | moderate |
| Pierre shale | marine | reptiles, fish, mollusks | low | moderate |
| Bearpaw shale | marine | reptiles, fish, mollusks | low | moderate |
| Greenhorn | marine | reptiles, fish, mollusks | low | moderate |
| Eagle sandstone | marine | mollusks | low | moderate |

Picnicking, walking for pleasure, camping, and fishing are the more popular activities. The number of participants is expected to increase in these activities that can be enjoyed by all ages (McCool and Frost 1987). Fishing is the most popular water-based recreational activity for Montanans and is expected to remain so.

Angler use in the Milk, lower Missouri, and Little Missouri River subbasins is low compared to angler use in the rest of the state. Only the Missouri River below Fort Peck Dam and Milk River support use levels comparable to streams in the upper Missouri River basin rivers. In 1989, the Milk River had 12,320 angler days and the Missouri River below Fort Peck had 10,747. In comparison, section 1 of the Big Hole River from Divide Creek to its mouth had 22,394 angler days in 1991, the Jefferson River had 15,260 angler days, and the Missouri River from its headwaters to Canyon Ferry Reservoir had 10,729 angler days (DFWP A undated).

In 1985, angler use of the lower Missouri River basin (below Fort Peck Reservoir), the Milk River subbasin, and the Yellowstone River basin (below the Big Horn River) totalled 4.3 percent of angler use statewide (DFWP 1989) (see Map 4-7). While angler use on rivers, streams, and reservoirs in the lower Missouri River basin is low compared to other parts of the state, the streams and reservoirs do provide an important and valued local recreation resource.

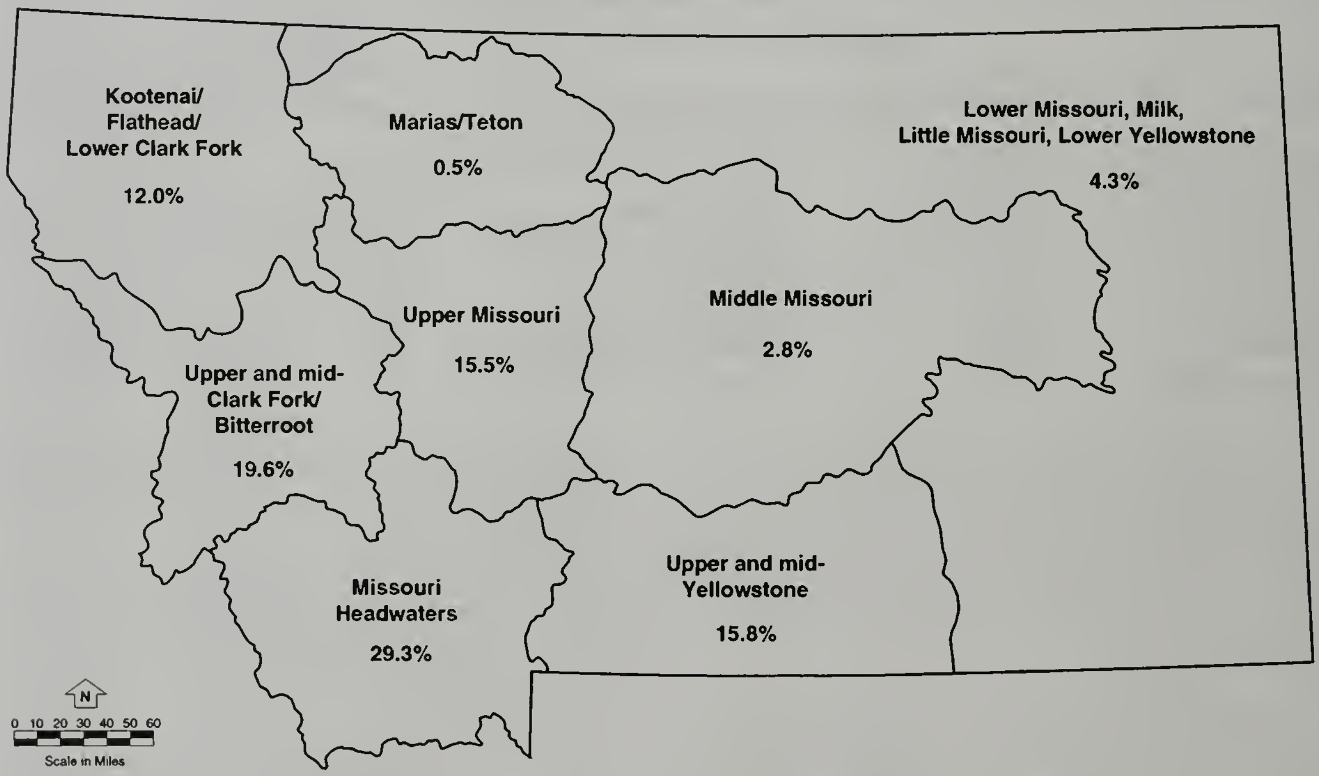
### LOWER MISSOURI RIVER SUBBASIN

The Missouri River immediately below Fort Peck Dam is a heavily used recreation corridor providing diverse opportunities for recreation. Highest angler

**Table 4-17. Participation by adult Montanans in 11 outdoor recreational activities - 1979 and 1985**

| Activity | 1979 Percentage participating | 1979 Median days | 1985 Percentage participating | 1985 Median days |
|---|---|---|---|---|
| Picnicking | 77.5 | 6 | 74.8 | 6 |
| Walking for pleasure | 71.9 | 20 | 77.1 | 30 |
| Fishing | 58.5 | 14 | 56.4 | 12 |
| Camping | 57.6 | 10 | 51.9 | 8 |
| Hunting | 35.2 | 10 | 37.6 | 10 |
| Bicycling | 32.8 | 20 | 38.6 | 20 |
| Motor boating | 32.5 | 6 | 32.6 | 5 |
| Bird watching/ nature study | 29.4 | 25 | 31.8 | 21 |
| Horseback riding | 18.8 | 10 | 22.3 | 6 |
| Snowmobiling | 14.8 | 5 | 16.3 | 5 |
| Cross-country skiing | 14.6 | 6 | 18.6 | 7 |

**Map 4-7. Distribution of fishing use among Montana river subbasins**


Kootenai/ Flathead/ Lower Clark Fork
12.0%
Marias/Teton
0.5%
Lower Missouri, Milk, Little Missouri, Lower Yellowstone
4.3%
Upper Missouri
15.5%
Middle Missouri
2.8%
Upper and mid-Clark Fork/ Bitterroot
19.6%
Missouri Headwaters
29.3%
Upper and mid-Yellowstone
15.8%
N
0 10 20 30 40 50 60
Scale in Miles

Notes:
Numbers shown are the percentage of total statewide fishing days occurring in each river subbasin determined during the 1985 DFWP fisheries survey.
Percentages may not total 100 due to rounding.
Adapted from DFWP 1989.

use occurs between the dam and Milk River with 4,747 angler days (475 per river mile) in 1989 (DFWP A undated). The river reach from the Milk River to the Montana/North Dakota state line is less heavily used, with 6,000 angler days (35 per river mile). The diverse aquatic habitat immediately below Fort Peck Dam, ease of access from public land, and excellent fishery all contribute to the high recreation use. Activities associated with the dredge ponds below the dam, besides fishing, include swimming, water skiing, scuba diving, picnicking, and camping. Both the Corps and DFWP manage developed recreation areas.

**Table 4-18. Lower Missouri River subbasin angler use**

| Stream/lake | 1989 Angler days/year | 1991 Angler days/year |
|---|---|---|
| Missouri River: | | |
| Fort Peck Dam-Milk River | 4,747 | 2,330 |
| Milk River-North Dakota | 6,000 | 3,636 |
| Poplar River | 696 | 2,212 |
| West Fork Poplar River | Unk | 79 |
| Middle Fork Poplar River | Unk | Unk |
| East Fork Poplar River | 111 | Unk |
| Redwater River | 1,882 | 162 |
| Big Muddy Creek | 88 | Unk |
| Whitetail Creek | 39 | Unk |
| Fort Peck Reservoir | 37,792 | 43,346 |

Unk = unknown
No angler use was reported for Olsen Coulee and Police, Coal, and Butte creeks.
Fort Peck Reservoir has been included for comparison.

SOURCE: DFWP A and B undated

Angler use on the major tributaries to the lower Missouri River—the Redwater River, Poplar River and its forks, and Big Muddy Creek—varies from low to moderate. Weather conditions from year to year—particularly the severity of winters—can dramatically affect the fishery and amount of angling use on the Poplar River and its forks (DFWP 1991; Needham 1993).

Other streams in this subbasin with proposed irrigation projects—Olsen Coulee, and Police, Coal, and Butte creeks—have no documented angler use (DFWP A and B undated). Whitetail Creek and the West, Middle, and East Forks of the Poplar have very low angler use (DFWP A and B undated; DFWP 1991). Shore fishing is the primary activity on these streams. Use is predominantly local.

## OUTFITTER USE IN THE LOWER MISSOURI RIVER SUBBASIN STUDY AREA

In May 1993, DNRC conducted a telephone survey of outfitters who use the lower Missouri River subbasin and Fort Peck Reservoir, where most local outfitting occurs. Of the nine outfitters contacted, five provide water-based outfitting services on streams and reservoirs in the Milk and lower Missouri River subbasins. Activity was concentrated on Fort Peck Reservoir, which accounted for 63 percent of the total estimated 46 trips made in 1992. Primary activities on Fort Peck Reservoir were typically a combination of power boating, fishing, and hunting. Other rivers used and the estimated total number of trips per outfitter in 1992 were:

- Milk River (2 trips)
- Rock Creek (2 trips)
- Missouri from Fort Peck Dam to Milk River (3 trips)
- Missouri River near the North Dakota border (10 trips)

The average trip was three days long and involved four clients, with almost all clients (92 percent) from out-of-state. All outfitters expected their business to increase in the future, depending on the economy and the fishery. Outfitters using Fort Peck Reservoir commented on the negative effects of low reservoir levels on their activities: poor access to parts of the reservoir previously used; submerged or exposed hazards to boats; and exposed spawning beds. They use other parts of the reservoir but with greater time and expense.

### MILK RIVER SUBBASIN

Streams in this subbasin provide both cold water and warm water fishing, primarily for local residents. Milk River tributaries that originate in the Bear Paw and Little Rocky mountains—Beaver Creek south of Havre; Little Boxelder, Clear, and Peoples creeks; and Beaver Creek south of Malta—all provide trout fishing opportunities in their upper reaches. Fishing pressure on these streams is low.

Beaver Creek County Park south of Havre provides opportunities for recreation in both developed and dispersed settings along 17 miles of this stream. Opportunities include fishing, camping, picnicking, hiking, horseback riding, and wildlife viewing. Winter activities include ice fishing, cross country skiing, sledding, and snowmobiling. Use levels are high during the summer and decrease to lower levels during the winter. Two reservoirs in the park—Bear Paw Lake and Beaver Creek Reservoir—have moderate levels of angler use (Table 4-19).

**Table 4-19.Milk River subbasin angler use**

| Stream | 1989<br>Angler days/year | 1991<br>Angler days/year |
|---|---|---|
| Beaver Creek (Hill County) | 95 | 535 |
| Bear Paw Lake | 3,338 | 3,575 |
| Beaver Creek Reservoir | 3,023 | 2,110 |
| Little Box Elder Creek | Unk | Unk |
| Clear Creek | 205 | 284 |
| Peoples Creek | 116 | Unk |
| Beaver Creek (Phillips County) | 121 | 190 |
| Battle Creek | 169 | Unk |
| Frenchmen Creek | Unk | Unk |
| Rock Creek | 714 | 332 |
| Milk River: | | |
| Fresno Dam-Havre | 1,557 | 2,393 |
| Havre-Malta | 6,040 | 4,754 |
| Malta-Hinsdale | 1,588 | 1,238 |
| Hinsdale-mouth | 3,135 | 2,436 |

Unk = unknown
No angler use was reported for Lost, Black, and Little coulees.

SOURCE:DFWP A and B undated

Milk River tributaries that originate on the prairies of Saskatchewan—Battle, Frenchman, and Rock creeks—provide warm water fishing opportunities for walleye, northern pike, and other species. Lower reaches of these tributaries near their confluence with the Milk River can provide excellent fishing. These streams have low levels of angler use. Other tributaries in the Milk River subbasin with proposed irrigation projects—Lost, Black, and Little coulees and West Fork Porcupine Creek—have no known angler use.

The Milk River sustains moderate levels of angler use (Table 4-19). Upper reaches above Havre and from Havre to Malta are more heavily used than the reach from Malta to Hinsdale where summer dewatering is common. Below Hinsdale, angler use increases to moderate levels again. Besides fishing, the Milk River also provides opportunities for boating, camping, and wildlife viewing.

The Marias River below Tiber Dam could be affected by reservations for the Hill County Water District. Like the Milk River, the Marias River has moderate levels of angler use and also provides opportunities for boating and camping.

### LITTLE MISSOURI RIVER SUBBASIN

Streams of this subbasin provide warm water fishing opportunities, primarily for local anglers. Low levels of angler use have been recorded for Beaver Creek near Wibaux and Boxelder Creek (Table 4-20) (DFWP A and B undated). The walleye fishery in Beaver Creek is locally known and valued (Stewart 1993). No angler use has been reported for other streams in this subbasin from the angler pressure surveys conducted by DFWP in 1989 and 1991. Local angler use of these streams may fluctuate from year to year, depending on weather, streamflows, and spring spawning conditions.

**Table 4-20. Little Missouri River subbasin angler use**

| Stream | 1989<br>Angler days/year | 1991<br>Angler days/year |
|---|---|---|
| Beaver Creek | 351 | 52 |
| Boxelder Creek | Unk | 155 |

Unk = unknown
No angler use was reported for the Little Missouri River, Rattlesnake, Spring, Little Beaver, Bone Pile, Mud, Duck, Dugout, Lame Steer, Yates, Hay, North Butte, Long Draw, Sherril, Hawksnest, Elkhorn, and Cottonwood creeks, Lampkin Gulch, and Freshwater Draw.

SOURCE: DFWP A and B undated

### SHERIDAN COUNTY GROUNDWATER AREA

Recreation opportunities in this portion of Sheridan County center on the Medicine Lake National Wildlife Refuge. Primary uses at the refuge are wildlife tours and observation, interpretive exhibits, and hunting for upland gamebirds (Rabenberg 1993). Angler use at Medicine Lake can vary dramatically depending on the severity of the winters and associated fish kills (Table 4-21). Estimated angler use dropped from 2,283 angler days in 1989 to 159 angler days in 1991. No documented angler use occurs on the numerous smaller lakes located northeast of Medicine Lake. Brush Lake, approximately 15 miles from Medicine Lake, is used for swimming and water skiing. Cabins at the lake are leased or owned by local residents. Clear Lake also provides opportunities for swimming, boating, picnicking, and camping. Low water levels in recent years have limited water-based activities. Big Muddy Creek provides limited fishing opportunities.

**Table 4-21. Sheridan County Groundwater Area angler use**

| Lake | 1989 Angler days/year | 1991 Angler days/year |
|---|---|---|
| Medicine Lake | 2,283 | 159 |

No angler use was reported for the following lakes: Brush, Capeneys, Clear, Dominek, Goose, Katy, Long, Tadpole, and White.

SOURCE: DFWP A and B undated

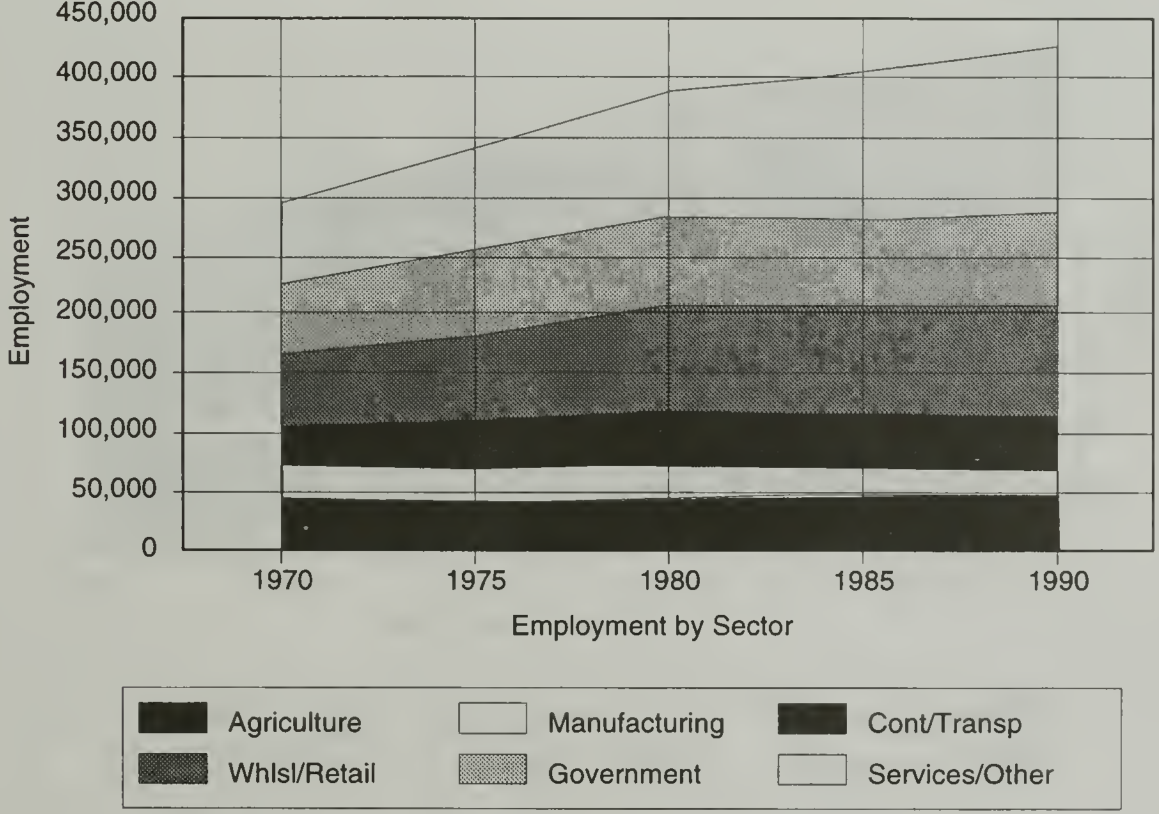
# SOCIOECONOMICS

## EMPLOYMENT

The relative importance of the various sectors of Montana's economy has changed somewhat over the past two decades (Figure 4-18). Employment in the services, finance, and other nonagriculture industrial sectors nearly doubled between 1970 and 1990, accounting for about one-third of Montana's total work force in 1990. Employment in government (federal, state, and local, including schools), wholesale and retail trade, construction, and transportation has gradually shifted over the last 20 years, comprising approximately 51 percent of Montana employment in 1990. Employment in the agriculture, minerals, and manufacturing sectors decreased by about 5 percent between 1970 and 1990. Farmers and ranchers have continued to increase their farm productivity while reducing the size of their workforce. The services industry had the greatest growth rate over the 1970-to-1990 period and in 1990 provided the largest portion of employment in the state and in most counties in Montana.

Employment trends in the lower Missouri River basin over the past 20 years differ markedly from statewide trends (Figure 4-19). Total employment peaked in 1980 at the height of the oil boom and has declined by 17 percent since that time. Service, finance, and other no-agricultural sector employment increased by 34 percent between 1970 and 1990 and comprised 27 percent of total employment in the basin by 1990. Over this same period, basin natural resources (agriculture and oil) and manufacturing employment declined by nearly 20 percent, while wholesale and retail trade employment increased slightly. Government employment in the lower Missouri River basin increased by about 11 percent between 1970 and 1990. Employment in the other economic sectors in the lower Missouri River basin changed very little over the 1970-to-1990 time period.

**Figure 4-18. Montana employement trends**



## INCOME

Over the past two decades, Montana's earning trends have generally followed the changes in employment (Figure 4-20). Between 1970 and 1990, relative earnings (1990 dollars) from the service, finance, and other nonagriculture sources increased by 35 percent. The importance of agricultural-related earnings declined to 3 percent of total earnings in 1985, but rebounded to 9 percent by 1990. Increased farm productivity, drought, and decreased demand have contributed to the fluctuating but declining farm earnings over the past 20 years. Earnings from the service, finance, and other nonagriculture sector are the largest source of income for both the state and the lower Missouri River basin.

Relative earnings in the lower Missouri River basin are dominated by the service sector, which has grown over the past 20 years to provide over 25 percent of basin income (Figure 4-21). During the same period, agricultural- related earning trends were similar to those in the rest of the state. In 1970, agricultural earnings comprised nearly 40 percent of all earnings in the basin. By 1985, basin agricultural earnings had declined to 7 percent of all earnings in the basin before rebounding to 19 percent by 1990.

## TAXATION

The different sectors of Montana's economy are taxed in a different manner and at varying rates. Agricultural land is assessed at 30 percent of its productive capacity. In 1992, irrigated land in Montana (1.48 million acres) was assessed at an average of $31.17 per acre and had a corresponding taxable valuation of $9.35 per acre (Montana Department of Revenue 1992). Nonirrigated farmland in Montana was assessed at $22.65 per acre, or 27 percent less than irrigated land. Improvements to agricultural property such as outbuildings and wells are taxed at 3.86 percent of market value. In 1992, total agricultural-related property in Montana (Class 3) had a taxable valuation of $141.4 million and represented about 8.7 percent of total statewide taxable value. Subbasin taxable valuation and receipts for 1992 are summarized in Tables 4-22 through 4-25.

The following sections describe agriculture's role in the lower Missouri River basin and corresponding subbasin economies.

**Figure 4-19. Lower Missouri River basin employement trends**

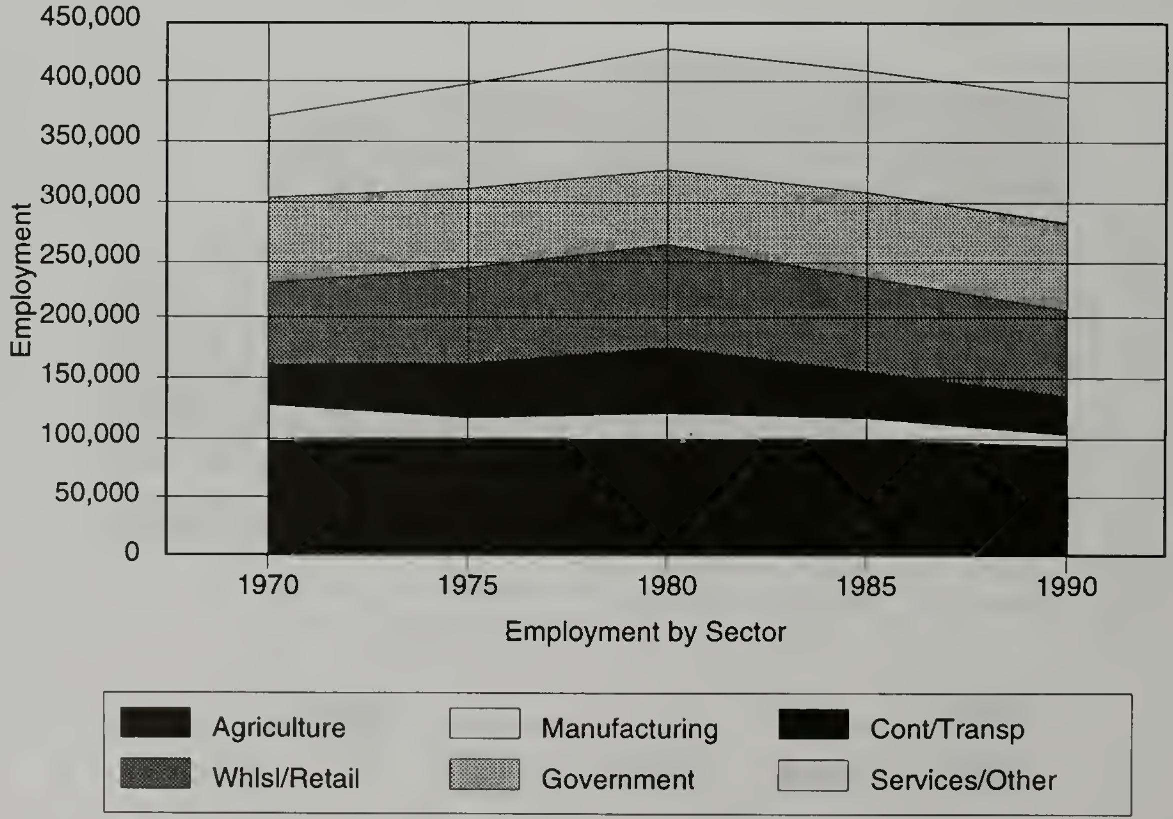


Figure 4-20. Montana earnings trends

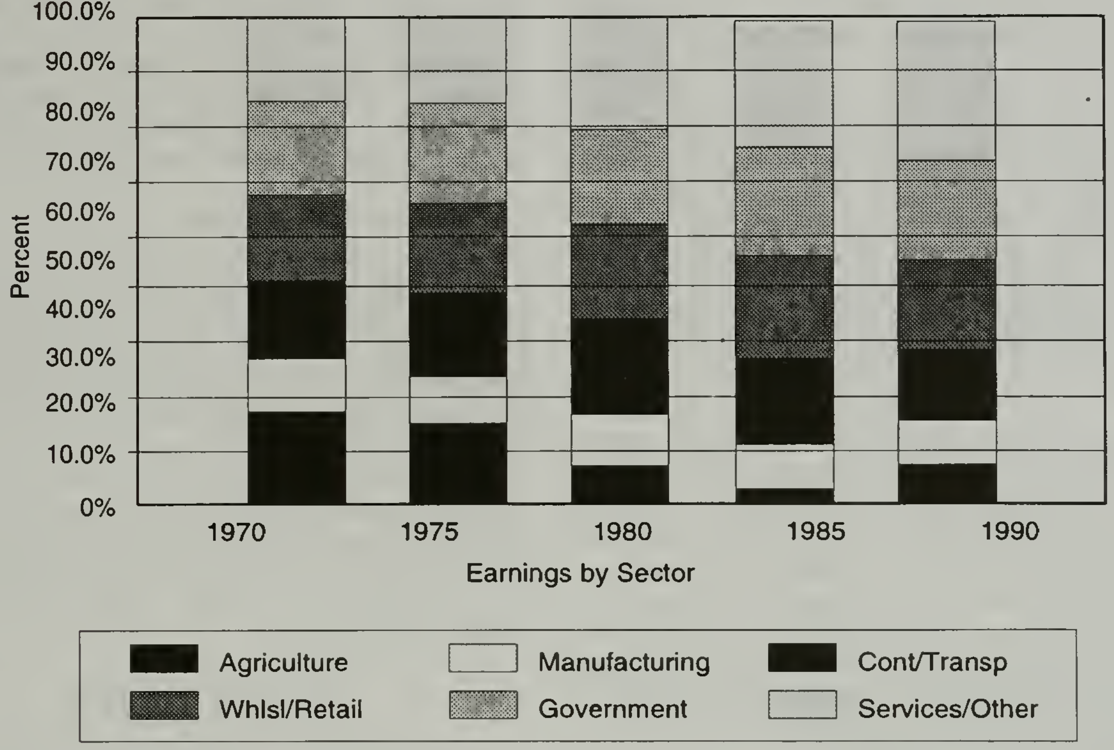
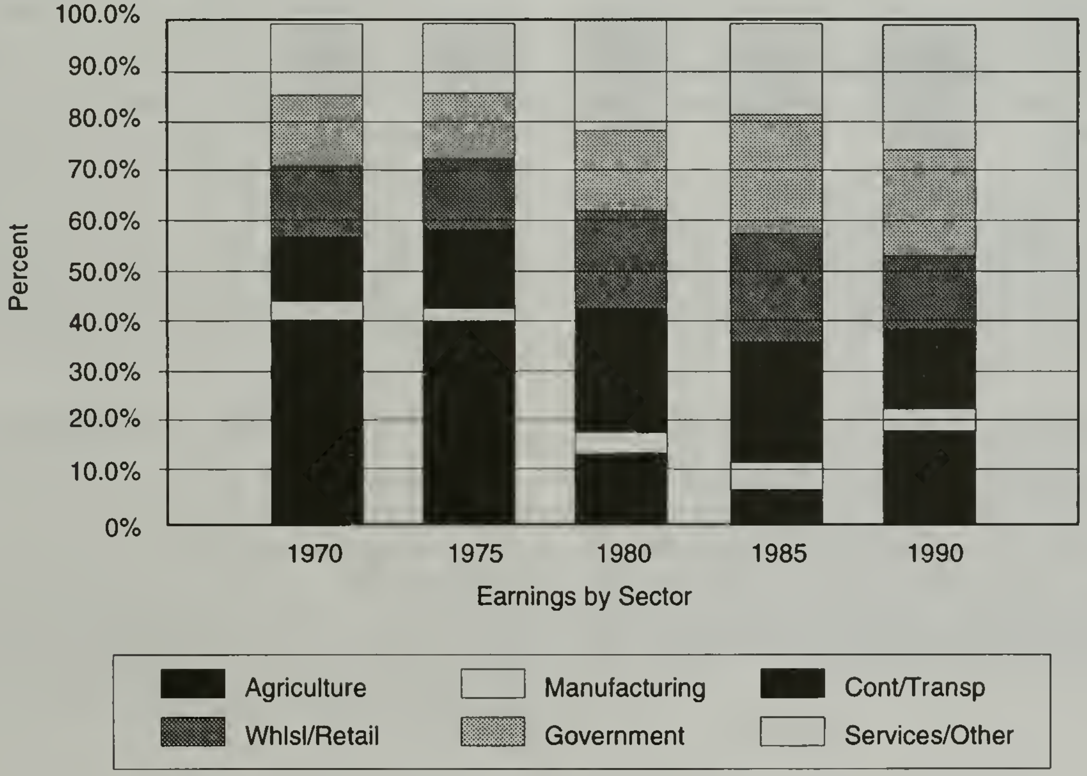


Figure 4-21. Lower Missouri River basin earnings trends



## LOWER MISSOURI RIVER BASIN AGRICULTURE ECONOMY

Farm-related employment in the 14 counties that comprise the lower Missouri River basin accounted for about one in five jobs in the basin during the period 1989-91, which was more than twice the statewide rate of 8.6 percent (Table 4-22). Basin farm employment decreased by 3.3 percent between 1979-81 and 1989-91, while statewide agricultural-related employment increased by 4.5 percent. Most of the statewide increase can be attributed to increases in the agriculture services sector. Farm employment in the lower Missouri River basin accounted for 22 percent of total statewide farm employment during 1989-91.

Farm-related income in the lower Missouri River basin averaged approximately 14 percent of total personal income in the basin during the period 1989 through 1991 (Table 4-22). This proportion was over three times the average 4.2 percent reported from 1979 through 1981. Farm income in the basin more than tripled between 1980 and 1990. Most of this increase is attributable to a doubling of government farm payments over the period; however, other temporary factors, including drought, depressed farm income during the early 1980s.

Agricultural sales in the lower Missouri River basin averaged $408.8 million per year during the 1989-91 period, or about one-fourth of total agricultural sales in Montana (Table4-22). Livestock sales in the basin comprised 44 percent of total basin agricultural sales, while crop sales averaged $228.5 million and made up 56 percent of the basin's agricultural sales.

Average irrigated alfalfa yields in the lower Missouri River basin increased from 2.5 tons per acre in the 1960s to about 3.0 tons per acre in the 1980s (Montana Crop and Livestock Reporting Service 1991) because of improved genetic stock and more efficient crop management.

Agricultural economies in the lower Missouri River basin are dominated by the Milk River and lower Missouri River subbasins. However, the Little Missouri River subbasin and Sheridan County Groundwater Area are both heavily dependent on agriculture even though they contribute less to the total basin economy. A detailed discussion of the economies of the four subbasins is presented in the following four sections.

### LOWER MISSOURI RIVER SUBBASIN

Approximately 40 percent of jobs in the lower Missouri River basin are located in the lower Missouri River subbasin. From 1989 through 1991, farm employment in the subbasin averaged 3,561 workers, or 20 percent of total employment (Table 4-23). Farm employment in the subbasin declined by about 6 percent between 1980 and 1990.

Between 1980 and 1990, total personal income, in terms of constant 1990 dollars, declined by 3 percent. Most of the decrease is attributable to declining energy prices and the loss of corresponding jobs and income. During 1989-91, farm income in the subbasin was approximately 13 percent of total personal income. Agricultural sales, which averaged $156.0 million per year between 1989 and 1991, were related mainly to crop sales. Cash receipts from livestock sales amounted to $66.9 million, 43 percent of total agricultural sales in the subbasin. Taxable valuation of agricultural property totaled $32.2 million in 1992, 37 percent of the subbasin's total taxable valuation.

### MILK RIVER SUBBASIN

The agricultural economy in the Milk River subbasin is similar to that of the lower Missouri River subbasin. Nearly half of all jobs in the lower Missouri River basin are located in the Milk River subbasin (Table 4-24). During the period 1989 through 1991, total employment in the subbasin averaged 20,091 persons. Farm employment, which averaged 3,845 jobs during 1989-91, accounted for nearly 20 percent of jobs in the subbasin. Similarly, farm income, which increased dramatically between 1979-81 and 1989-91, comprised about 13 percent of total income in the basin. Cash receipts from agricultural sales were principally related to the sale of crops and averaged $219.2 million during 1989-91. During 1992, taxable valuation on agricultural property in the subbasin was $40.2 million, about 40 percent of total taxable valuation in the subbasin.

### LITTLE MISSOURI RIVER SUBBASIN

The economy of the Little Missouri River subbasin depends more on agriculture than does either the lower Missouri River subbasin or the Milk River subbasin. In the period 1989-91, approximately 35 percent of subbasin employment and 17 percent of subbasin total personal income were directly attributable to agriculture (Table 4-25). Approximately 12 percent of the lower Missouri River basin's agricultural employment economy was related to farm and ranch activities in the Little Missouri River subbasin. Cash receipts from livestock marketing made up about 83 percent of total agricultural sales in the subbasin during 1989-91, while crop receipts totaled $8.0 million or 17 percent of agricultural sales. In 1992, 40 percent of the total taxable valuation in the subbasin was attributable to the valuation on agricultural property.

### SHERIDAN COUNTY GROUNDWATER AREA

The economy of the Sheridan County Groundwater Area is similar to that of the Little Missouri River subbasin (Table 4-26). During the period 1989 through 1991, 29 percent of total employment and 14 percent of total personal income in the area was related to agriculture. Between 1980 and 1990, farm employment decreased by approximately 12 percent while farm income increased by over 200 percent. The large increase in farm income is attributable to the poor farm economy during the late 1970s and early 1980s.

Total agricultural sales in the area decreased from $40.9 million per year in 1980 to $24.0 million in 1990 (in terms of 1990 dollars). Cash receipts from crop marketings made up approximately 75 percent of total agricultural sales in the area during 1989 through 1991, while sales of livestock averaged $5.9 million and comprised 25 percent of agricultural sales. In 1992, taxable valuation in the Sheridan County Groundwater Area totaled $12.0 million, of which 47 percent was the taxable valuation on agricultural property.

**Table 4-22. Economic baseline data - lower Missouri River basin**

| | Montana | | | Lower Missouri River Basin | | | Lower Missouri River Basin Percent of Montana | |
|---|---|---|---|---|---|---|---|---|
| **Category** | **Average 1979-81** | **Average 1989-91** | **Percent Change** | **Average 1979-81** | **Average 1989-91** | **Percent Change** | **1979-81** | **1989-91** |
| Total employment | 393,580 | 429,715 | 9.2% | 43,467 | 38,918 | -10.5% | 11.0% | 9.1% |
| Farm employment | 35,416 | 36,996 | 4.5% | 8,513 | 8,235 | -3.3% | 24.0% | 22.3% |
| Percent of total | 9.0% | 8.6% | | 19.6% | 21.2% | | | |
| Totalpersonal income ($000) | $10,992,659 | $11,901,578 | 8.3% | $963,056 | $970,782 | 0.8% | 8.8% | 8.2% |
| Farm income ($000) | 251,648 | 502,771 | 99.8% | 40,579 | 132,047 | 225.4% | 16.1% | 26.3% |
| Percent of total | 2.3% | 4.2% | | 4.2% | 13.6% | | | |
| Total ag sales ($000) | $ 2,357,394 | $ 1,764,832 | -25.1% | $593,174 | $408,780 | -31.1% | 25.2% | 23.2% |
| Livestock sales ($000) | 1,322,918 | 1,036,496 | -21.7% | 231,470 | 180,261 | -22.1% | 17.5% | 17.4% |
| Percent of total | 56.1% | 58.7% | | 39.0% | 44.1% | | | |
| Crop | sales | ($000) | 1,034,476 | 728,336 | -29.6% | 361,703 | 228,519 | -36.8% |
| 35.0% | 31.4% | | | | | | | |
| Percent of total | 43.9% | 41.3% | | 61.0% | 55.9% | | | |

Note: All dollar amounts expressed in terms of 1990 dollars.
Source: U.S.Bureau of Economic Analysis, Regional Economic Information System, Unpublished computerized data. Washington, D.C. 1993

## Table 4-23. Economic baseline data - lower Missouri River subbasin

| Category | Average 1979-81[a] | Subbasin total Average 1989-91 | Percentage Change | Percentage of Lower Missouri basin[b] 1979-81 | 1989-91 |
|---|---|---|---|---|---|
| **Economic Data:** | | | | | |
| Total employment | 20,289 | 17,792 | -12.3% | 41.7% | 41.0% |
| Farm employment | 3,805 | 3,561 | -6.4% | 40.1% | 38.7% |
| Percentage of total | 18.8% | 20.0% | | | |
| Total personal income ($000) | $369,817 | $358,673 | -3.0% | 33.7% | 32.8% |
| Farm income ($000) | 13,875 | 46,892 | 238.0% | 31.9% | 32.3% |
| Percentage of total | 3.8% | 13.1% | | | |
| Total ag sales ($000) | $243,086 | $156,052 | -35.8% | 37.1% | 34.9% |
| Livestock sales ($000) | $88,518 | $66,900 | -24.4% | 34.3% | 33.5% |
| Percentage of total | 36.4% | 42.9% | | | |
| Crop sales ($000) | $154,568 | $89,153 | -42.3% | 39.0% | 36.1% |
| Percentage of total | 63.6% | 57.1% | | | |
| **Tax Data:** | | **1992** | | **1992** | |
| Subbasin taxable valuation ($000) | | $86,380,665 | | 39.3% | |
| Ag taxable valuation ($000) | | $32,238,874 | | 37.2% | |
| Percentage of total | | 37.3% | | | |
| Average mill levy | | 295.06 | | | |

[a] All income and sales dollar amounts are in terms of 1990 dollars.
[b] Percentage of basin totals based on sum of all subbasins.
SOURCE: U.S. Department of Commerce 1993

## Table 4-24. Economic baseline data - Milk River subbasin

| Category | Subbasin total Average 1979-81[a] | Average 1989-91 | Percent Change | Percent of Lower Missouri basin[b] 1979-81 | 1989-91 |
|---|---|---|---|---|---|
| Economic Data: | | | | | |
| Total employment | 21,692 | 20,091 | -7.4% | 44.6% | 46.3% |
| Farm employment | 3,800 | 3,845 | 1.2% | 40.1% | 41.8% |
| Percentage of total | 17.5% | 19.1% | | | |
| Total personal income ($000) | 552,499 | 572,770 | 3.7% | 50.4% | 52.3% |
| Farm income ($000) | 17,717 | 72,352 | 308.4% | 40.7% | 49.8% |
| Percentage of total | 3.2% | 12.6% | | | |
| Total ag sales ($000) | $300,186 | $219,244 | -27.0% | 45.9% | 49.1% |
| Livestock sales ($000) $108,450 | $87,447 | -19.4% | 42.0% | 43.7% | |
| Percentage of total | 36.1% | 39.9% | | | |
| Crop sales ($000) | $191,736 | $131,797 | -31.3% | 48.4% | 53.3% |
| Percentage of total | 63.9% | 60.1% | | | |
| **Tax Data** | **1992** | | | **1992** | |
| Subbasin taxable valuation ($000) | $99,435,216 | | | 45.3% | |
| Ag taxable valuation ($000) | $40,164,529 | | | 46.3% | |
| Percentage of total | 40.4% | | | | |
| Average mill levy | 266.74 | | | | |

[a] All income and sales dollar amounts are in terms of 1990 dollars.
[b] Percentage of basin totals based on sum of all subbasins.
SOURCE: U.S. Department of Commerce 1993

**Table 4-25. Economic baseline data - Little Missouri River subbasin**

| | — Subbasin total — | | | — Percentage of — Lower Missouri basin[b] | |
|---|---|---|---|---|---|
| Category | Average 1979-81[a] | Average 1989-91 | Percent Change | 1979-81 | 1989-91 |
| **Economic Data:** | | | | | |
| Total employment | 3,726 | 3,203 | -14.0% | 7.7% | 7.4% |
| Farm employment | 1,131 | 1,124 | -.6% | 11.9% | 12.2% |
| Percentage of total | 30.4% | 35.1% | | | |
| Total personal income ($000) | 98,633 | 89,093 | -9.7% | 9.0% | 8.1% |
| Farm income ($000) | 8,726 | 15,500 | 77.6% | 20.1% | 10.7% |
| Percentage of total | 8.8% | 17.4% | | | |
| Total ag sales ($000) | $70,111 | $47,644 | -32.0% | 10.7% | 10.7% |
| Livestock sales ($000) $51,871 | $39,603 | -23.7% | 20.1% | 19.8% | |
| Percentage of total | 74.0% | 83.1% | | | |
| Crop sales ($000) | $18,241 | $8,042 | -55.9% | 4.6% | 3.3% |
| Percentage of total | 26.0% | 16.9% | | | |
| **Tax Data** | | 1992 | | 1992 | |
| Subbasin taxable valuation ($000) | | $21,709,213 | | 9.9% | |
| Ag taxable valuation ($000) | | $8,678,103 | | 10.0% | |
| Percentage of total | | 40.0% | | | |
| Average mill levy | | 253.70 | | | |

[a] All income and sales dollar amounts are in terms of 1990 dollars.
[b] Percentage of basin totals based on sum of all subbasins.
SOURCE: U.S. Department of Commerce 1993

**Table 4-26. Economic baseline data - Sheridan County Groundwater Area**

| Category | Subbasin total<br>Average 1979-81[a] | <br>Average 1989-91 | <br>Percent Change | Percentage of Lower Missouri basin[b]<br>1979-81 | <br>1989-91 |
|---|---|---|---|---|---|
| **Economic Data:** | | | | | |
| Total employment | 2,923 | 2,278 | -22.1% | 6.0% | 5.3% |
| Farm employment | 751 | 665 | -11.5% | 7.9% | 7.2% |
| Percentage of total | 25.7% | 29.2% | | | |
| Total personal income ($000) | $76,182 | $73,914 | -3.0% | 6.9% | 6.8% |
| Farm income ($000) | $3,185 | $10,581 | 232.2% | 7.3% | 7.3% |
| Percentage of total | 4.2% | 14.3% | | | |
| Total ag sales ($000) | $40,983 | $23,989 | -41.5% | 6.3% | 5.4% |
| Livestock sales ($000) | $9,508 | $5,935 | -37.6% | 3.7% | 3.0% |
| Percentage of total | 23.2% | 24.7% | | | |
| Crop sales ($000) | $31,474 | $18,054 | -42.6% | 7.9% | 7.3% |
| Percentage of total | 76.8% | 75.3% | | | |
| **Tax Data** | | 1992 | | 1992 | |
| Area taxable valuation ($000) | | $12,018,054 | | 5.5% | |
| Ag taxable valuation ($000) | | $5,605,290 | | 6.5% | |
| Percentage of total | | 46.6% | | | |
| Average mill levy | | 264.02 | | | |

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[a] All income and sales dollar amounts are in terms of 1990 dollars.
[b] Percentage of basin totals based on sum of all subbasins.
SOURCE: U.S. Department of Commerce 1993

## CHAPTER FIVE

# ALTERNATIVES CONSIDERED IN THIS EIS

## INTRODUCTION

DNRC developed four hypothetical alternatives to help assess the environmental impacts that would occur as a result of the Board's action on the proposed reservations in the lower Missouri River basin. The alternatives illustrate the effects of different water use emphases, and encompass a reasonable range of actions that could be taken by the Board. These alternatives do not limit the Board in approving, modifying, denying, or assigning priorities to the requests for reservations.

In developing the alternatives, DNRC took into account that the Board is required to establish priorities among the reservations. DNRC assigned municipal reservations the highest priority under each alternative because of the importance of sufficient water supplies for communities and the relatively small amount of water requested. The priority of other uses was emphasized differently among alternatives. Because of the complexity of the issues involving aquifers in Sheridan County, DNRC developed a separate set of alternatives to analyze the reservations requested in the Sheridan County Groundwater Area and these are treated separately in the alternative discussion.

The alternatives developed by DNRC are described below and analyzed in Chapter Six.

## ALTERNATIVES FOR THE LOWER MISSOURI, MILK, AND LITTLE MISSOURI RIVER SUBBASINS

### CONSUMPTIVE USE ALTERNATIVE

This alternative emphasizes reservations for future irrigation and municipal use. It is intended to reflect what would happen if the Board were to grant all reservations requested, with an emphasis on consumptive water use. Municipalities would receive first priority, followed by irrigation projects. Any water remaining after municipal and irrigation reservations are met would be reserved for instream use. Table 5-1 identifies the reservations included in this alternative and their relative priorities.

### INSTREAM ALTERNATIVE

This alternative emphasizes instream reservations for fish, wildlife, and recreation. It also seeks to protect wildlife habitat, wetlands, and riparian resources. As in all other alternatives, municipalities would be given first priority. DFWP's instream requests would be granted next. Third priority would be given to reservations for irrigation projects that DNRC considers economically feasible. Water would not be reserved for irrigation projects, or portions of them, that would damage substantial amounts of riparian wildlife habitat and wetlands. Table 5-1 identifies the reservations included in this alternative and their relative priorities. Table 5-2 lists irrigation projects which have been reduced under this alternative.

### COMBINATION ALTERNATIVE

In this alternative, municipal requests would be granted with first priority. Irrigation projects that are economically feasible would receive second priority, but projects or portions of projects that have insurmountable conflicts with existing land uses would be eliminated. Table 5-2 lists irrigation projects that would be reduced under this alternative. On streams where not enough water is available for all irrigation projects proposed, the available water would be allocated to the most feasible projects. Any water remaining after other reservations are fulfilled would be reserved for instream use.

## Table 5-1. Reservation requests included under each alternative

### Milk River subbasin–Milk River drainage

| APPLICANT/ PROJECT | SOURCE | TYPE OF RESERVATION | AMOUNT (af) | ALTERNATIVES | | | |
|---|---|---|---|---|---|---|---|
| | | | | CONSUMPTIVE USE | INSTREAM | COMBINATION | NO ACTION |
| Chinook | Milk River wells | Municipal | 800 | ▩ | ▩ | ▩ | ☐ |
| Havre | Milk River wells | Municipal | 2,025 | ▩ | ▩ | ▩ | ☐ |
| Harlem | Milk River well | Municipal | 565 | ▩ | ▩ | ▩ | ☐ |
| HCWD | Marias River GW/SW | Municipal | 110 | ▩ | ▩ | ▩ | ☐ |
| Malta | Milk River well | Municipal | 137 | ▩ | ▩ | ▩ | ☐ |
| LI-241 | Lost Coulee | Irrigation | 122 | ▨ | ☐ | ☐ | ☐ |
| BL-131 | Trib. Black Coulee | Irrigation | 164 | ▨ | ☐ | ☐ | ☐ |
| BL-171 | Link Coulee/Battle Creek | Storage/ Irrigation | 172 | ▨ | ☐ | ☐ | ☐ |
| BL-181 | Battle Creek | Storage/ Irrigation | 10,600 | ▨ | ☐ | ▨ | ☐ |
| VA-71 | Milk River | Irrigation | 590 | ▨ | ☐ | ▨ | ☐ |
| VA-171 | Well | Irrigation | 337 | ▨ | ░ | ▨ | ☐ |
| VA-211 | Milk River | Irrigation | 226 | ▨ | ☐ | ▨ | ☐ |
| VA-261 | Milk River | Irrigation | 365 | ▨ | ☐ | ▨ * | ☐ |
| VA-291 | Milk River | Irrigation | 412 | ▨ | ☐ | ▨ | ☐ |
| VA-521 | Milk River | Irrigation | 289 | ▨ | ☐ | ▨ | ☐ |
| DFWP | Beaver Creek (Hill County) | Instream | 5,068 | ░ | ▩ | ░ | ☐ |
| DFWP | Little Boxelder Creek | Instream | 724 | ░ | ▩ | ░ | ☐ |
| DFWP | Clear Creek | Instream | 3,620 | ░ | ▩ | ░ | ☐ |
| DFWP | Battle Creek | Instream | 15,078 | ░ | ▩ | ░ | ☐ |
| DFWP | Peoples Creek | Instream | 724 | ░ | ▩ | ░ | ☐ |
| DFWP | Beaver Creek #1 (Phillips County) | Instream | 145 | ░ | ▩ | ░ | ☐ |
| DFWP | Beaver Creek #2 (Phillips County) | Instream | 15,950 | ░ | ▩ | ░ | ☐ |
| DFWP | Frenchman River | Instream | 25,314 | ░ | ▩ | ░ | ☐ |
| DFWP | Rock Creek | Instream | 27,600 | ░ | ▩ | ░ | ☐ |

▩ First priority of use

▨ Second priority of use

░ Third priority of use

☐ Not included in this alternative

* Irrigation reservations that have been reduced: those that would damage riparian wildlife habitat under the Instream Alternative; and those with land use conflicts under the Combination Alternative.

### Lower Missouri subbasin–Lower Missouri River drainage

| APPLICANT/ PROJECT | SOURCE | TYPE OF RESERVATION | AMOUNT (af) | ALTERNATIVES | | | |
|---|---|---|---|---|---|---|---|
| | | | | CONSUMPTIVE USE | INSTREAM | COMBINATION | NO ACTION |
| Circle | Redwater River/ well | Municipal | 78 | ■ | ■ | ■ | |
| Culbertson | Missouri River | Municipal | 365 | ■ | ■ | ■ | |
| Fort Peck | Missouri River | Municipal | 100 | ■ | ■ | ■ | |
| Plentywood | Big Muddy Creek/ well | Municipal | 235 | ■ | ■ | ■ | |
| Poplar | Missouri River/wells | Municipal | 448 | ■ | ■ | ■ | |
| Wolf Point | Missouri River/wells | Municipal | 504 | ■ | ■ | ■ | |
| VA-01 | Missouri River | Irrigation | 176 | ▨ | | ▨ * | |
| VA-02 | Missouri River | Irrigation | 2,325 | ▨ | | | |
| VA-03 | Missouri River | Irrigation | 2,203 | ▨ | | ▨ * | |
| VA-231 | Missouri River | Irrigation | 745 | ▨ | | ▨ * | |
| MC-01 | Missouri River | Irrigation | 501 | ▨ | ░ * | ▨ | |
| MC-03 | Missouri River | Irrigation | 807 | ▨ | ░ | ▨ | |
| MC-04 | Missouri River | Irrigation | 265 | ▨ | | ▨ | |
| MC-05 | Missouri River | Irrigation | 696 | ▨ | | ▨ | |
| MC-5A | Missouri River | Irrigation | 858 | ▨ | | ▨ | |
| MC-06 | Missouri River | Irrigation | 698 | ▨ | ░ * | ▨ | |
| MC-6A | Missouri River | Irrigation | 257 | ▨ | | ▨ | |
| MC-08 | Missouri River | Irrigation | 2,989 | ▨ | | ▨ | |
| MC-09 | Missouri River | Irrigation | 798 | ▨ | ░ * | ▨ | |
| MC-9A | Missouri River | Irrigation | 57 | ▨ | | | |
| MC-10 | Missouri River | Irrigation | 812 | ▨ | | ▨ | |
| MC-11 | Missouri River | Irrigation | 2,128 | ▨ | | ▨ | |
| MC-12 | Missouri River | Irrigation | 1,246 | ▨ | | ▨ | |
| MC-99 | Missouri River | Irrigation | 2,187 | ▨ | | ▨ * | |

### Lower Missouri subbasin–Lower Missouri River drainage (continued)

| APPLICANT/ PROJECT | SOURCE | TYPE OF RESERVATION | AMOUNT (af) | ALTERNATIVES | | | |
|---|---|---|---|---|---|---|---|
| | | | | CONSUMPTIVE USE | INSTREAM | COMBINATION | NO ACTION |
| RI-01 | Missouri River | Irrigation | 3,667 | ▨ | | ▨ | |
| RI-02 | Missouri River | Irrigation | 651 | ▨ | ░ | ▨ | |
| RI-03 | Missouri River | Irrigation | 1,896 | ▨ | ░ * | ▨ | |
| RI-04 | Missouri River | Irrigation | 472 | ▨ | ░ | ▨ | |
| RI-05 | Missouri River | Irrigation | 1,230 | ▨ | | ▨ * | |
| RI-06 | Missouri River | Irrigation | 972 | ▨ | | ▨ * | |
| RI-07 | Missouri River | Irrigation | 2,441 | ▨ | | | |
| RI-08 | Missouri River | Irrigation | 658 | ▨ | | ▨ | |
| RI-09 | Missouri River | Irrigation | 2,188 | ▨ | | ▨ * | |
| RI-10 | Missouri River | Irrigation | 1,519 | ▨ | ░ * | ▨ | |
| RI-11A | Missouri River | Irrigation | 441 | ▨ | | ▨ | |
| RI-11 | Missouri River | Irrigation | 1,606 | ▨ | ░ * | ▨ | |
| RI-12 | Missouri River | Irrigation | 1,635 | ▨ | ░ * | ▨ | |
| RI-13 | Missouri River | Irrigation | 835 | ▨ | | ▨ | |
| RI-14 | Missouri River | Irrigation | 2,128 | ▨ | | ▨ | |
| RI-15 | Missouri River | Irrigation | 3,010 | ▨ | | ▨ | |
| CBI-1 | Missouri River | Irrigation | 2,121 | ▨ | ░ | ▨ * | |
| CBI-2 | Missouri River | Irrigation | 2,435 | ▨ | | ▨ * | |
| CBI-3 | Missouri River | Irrigation | 4,190 | ▨ | | ▨ | |
| CBI-4 | Missouri River | Irrigation | 4,451 | ▨ | | | |
| CBI-5 | Missouri River | Irrigation | 570 | ▨ | | ▨ | |
| CBI-6 | Missouri River | Irrigation | 677 | ▨ | | ▨ * | |
| CBI-7 | Missouri River | Irrigation | 2,191 | ▨ | | | |
| CBI-8 | Missouri River | Irrigation | 449 | ▨ | | ▨ | |

### **Lower Missouri subbasin–Lower Missouri River drainage** (continued)

| APPLICANT/ PROJECT | SOURCE | TYPE OF RESERVATION | AMOUNT (af) | ALTERNATIVES CONSUMPTIVE USE | INSTREAM | COMBINATION | NO ACTION |
|---|---|---|---|---|---|---|---|
| CBI-9 | Missouri River | Irrigation | 646 | ▩ | | | |
| CBI-10 | Missouri River | Irrigation | 2,096 | ▩ | | ▩ * | |
| CBI-11 | Missouri River | Irrigation | 4,084 | ▩ | | ▩ * | |
| CBI-12 | Missouri River | Irrigation | 3,939 | ▩ | | | |
| CBI-13 | Missouri River | Irrigation | 33,157 | ▩ | | | |
| CBI-14 | Missouri River | Irrigation | 609 | ▩ | ░ * | ▩ | |
| CBI-15 | Missouri River | Irrigation | 1,504 | ▩ | | ▩ | |
| CBI-16 | Missouri River | Irrigation | 2,380 | ▩ | | ▩ | |
| CBI-17 | Missouri River | Irrigation | 1,351 | ▩ | ░ * | ▩ * | |
| CBI-18 | Missouri River | Irrigation | 3,442 | ▩ | | | |
| CBI-19 | Missouri River | Irrigation | 1,217 | ▩ | ░ * | ▩ | |
| CBI-20 | Missouri River | Irrigation | 548 | ▩ | | | |
| CBI-21 | Missouri River | Irrigation | 1,058 | ▩ | | ▩ | |
| DFWP | Missouri River - reach #7 | Instream | 3,263,500[a] | ░ | ▩ | ░ | |
| DFWP | Missouri River - reach #8 | Instream | 3,748,500[a] | ░ | ▩ | ░ | |
| DFWP | Redwater River - reach #1 | Instream | 12,792 | ░ | ▩ | ░ | |
| DFWP | Redwater River - reach #2 | Instream | 14,200[a] | ░ | ▩ | ░ | |

| | |
|---|---|
| ■ | First priority of use |
| ▩ | Second priority of use |
| ░ | Third priority of use |
| ☐ | Not included in this alternative |

[a] Instream flow requests that have been reduced to ½ the average annual flow

### **Little Missouri subbasin–Poplar River drainage** (continued)

| APPLICANT/ PROJECT | SOURCE | TYPE OF RESERVATION | AMOUNT (af) | ALTERNATIVES CONSUMPTIVE USE | INSTREAM | COMBINATION | NO ACTION |
|---|---|---|---|---|---|---|---|
| Scobey | Poplar River/well | Municipal | 168 | ■ | ■ | ■ | |
| DA-21 | S.F. Whitetail Creek | Irrigation | 38 | ▩ | ░ | ▩ | |
| DA-31 | Groundwater | Irrigation | 208 | ▩ | | | |
| DA-32 | Groundwater | Irrigation | 92 | ▩ | | | |
| DA-51 | Poplar River | Irrigation | 68 | ▩ | | ▩ | |
| DA-71 | Groundwater | Irrigation | 502 | ▩ | | ▩ | |
| DA-131 | UT M.F. Poplar River | Irrigation | 122 | ▩ | | | |
| DA-151 | Groundwater | Irrigation | 316 | ▩ | | ▩ | |
| DA-152 | UT Poplar River | Irrigation | 9 | ▩ | ░ | ▩ | |
| DA-153 | UT Poplar River | Irrigation | 119 | ▩ | | | |
| DA-161 | Police Creek | Irrigation | 32 | ▩ | | | |
| DA-181 | UT M.F. Poplar River | Irrigation | 120 | ▩ | | | |
| DA-182 | UT M.F. Poplar River | Irrigation | 45 | ▩ | ░ | ▩ | |
| DA-211 | E.F. Poplar River | Irrigation | 82 | ▩ | | | |
| DA-221 | Spring, Olsen Coulee | Irrigation | 320 | ▩ | | ▩ | |
| DA-251 | Springs, Coal Creek | Irrigation | 95 | ▩ | | ▩ | |
| DA-252 | Springs, Coal Creek | Irrigation | 156 | ▩ | | ▩ | |
| DA-261 | Poplar River | Irrigation | 158 | ▩ | | | |
| DA-281 | Groundwater | Irrigation | 235 | ▩ | | | |
| DA-291 | UT E.F. Poplar River | Irrigation | 228 | ▩ | | | |
| DA-341 | Poplar River | Irrigation | 84 | ▩ | | ▩ | |
| DA-371 | UT Butte Creek | Irrigation | 3 | ▩ | ░ | ▩ | |
| DFWP | E.F. Poplar River | Instream | 6,870 | ░ | ▩ | ░ | |
| DFWP | M.F. Poplar River | Instream | 10,685 | ░ | ▩ | ░ | |
| DFWP | Poplar River | Instream | 21,207 | ░ | ▩ | ░ | |
| DFWP | W.F. Poplar River | Instream | 13,121 | ░ | ▩ | ░ | |

### Little Missouri subbasin–Little Missouri River drainage

| APPLICANT/ PROJECT | SOURCE | TYPE OF RESERVATION | AMOUNT (af) | ALTERNATIVES | | | |
|---|---|---|---|---|---|---|---|
| | | | | CONSUMPTIVE USE | INSTREAM | COMBINATION | NO ACTION |
| CT-011 | Little Missouri River | Irrigation | 425 | ▓ | ░ | ▓ | |
| CT-012 | North Butte Creek | Irrigation | 260 | ▓ | | | |
| CT-131 | Little Missouri River | Irrigation | 240 | ▓ | ░ | ▓ | |
| CT-141 | UT Long Draw | Irrigation | 120 | ▓ | | ▓ | |
| CT-161 | Elkhorn Creek | Irrigation | 42 | ▓ | | ▓ | |
| CT-162 | UT Elkhorn Creek | Irrigation | 50 | ▓ | | ▓ | |
| CT-181 | Cottonwood Creek | Irrigation | 225 | ▓ | | ▓ | |
| CT-191 | Little Missouri River | Irrigation | 247 | ▓ | | | |
| CT-241 | Little Missouri River | Irrigation | 269 | ▓ | | ▓ | |
| CT-243 | UT Beaver Dam Creek | Irrigation | 9 | ▓ | | ▓ | |
| CT-244 | NF Beaver Dam Creek | Irrigation | 105 | ▓ | | ▓ | |
| DFWP | Little Missouri River | Instream | 32,562 | ░ | ▓ | ░ | |

### Little Missouri subbasin–Boxelder Creek drainage

| APPLICANT/ PROJECT | SOURCE | TYPE OF RESERVATION | AMOUNT (af) | ALTERNATIVES | | | |
|---|---|---|---|---|---|---|---|
| | | | | CONSUMPTIVE USE | INSTREAM | COMBINATION | NO ACTION |
| CT-121 | Boxelder Creek | Irrigation | 255 | ▓ | | | |
| CT-122 | Lampkin Gulch | Irrigation | 90 | ▓ | | | |
| CT-151 | Sherril Creek | Irrigation | 54 | ▓ | | ▓ | |
| CT-152 | UT Boxelder Creek | Irrigation | 17 | ▓ | | ▓ | |
| CT-153 | Hawksnest Creek | Irrigation | 84 | ▓ | | ▓ | |
| CT-154 | UT Boxelder Creek | Irrigation | 14 | ▓ | | ▓ | |
| CT-171 | Freshwater Draw | Irrigation | 165 | ▓ | | ▓ | |
| CT-221 | Boxelder Creek | Irrigation | 311 | ▓ | | ▓ | |
| CT-251 | Boxelder Creek | Irrigation | 290 | ▓ | ░ | ▓ | |
| CT-261 | UT East Lo Creek | Irrigation | 20 | ▓ | | ▓ | |
| CT-262 | UT Lo Creek | Irrigation | 3 | ▓ | | ▓ | |
| CT-310 | UT Boxelder Creek | Irrigation | 45 | ▓ | | ▓ | |
| CT-320 | Boxelder Creek | Irrigation | 39 | ▓ | | | |
| CT-330 | Boxelder Creek | Irrigation | 130 | ▓ | ░ | ▓ | |
| CT-370 | Boxelder Creek | Irrigation | 107 | ▓ | | | |
| CT-380 | Boxelder Creek | Irrigation | 36 | ▓ | | | |
| DFWP | Box Elder Creek | Irrigation | 20,682 | ░ | ▓ | ░ | |

▓ First priority of use

▒ Second priority of use

░ Third priority of use

☐ Not included in this alternative

a Instream flow requests that have been reduced to ½ the average annual flow

## Little Missouri subbasin–Little Beaver Creek drainage

| APPLICANT/ PROJECT | SOURCE | TYPE OF RESERVATION | AMOUNT (af) | ALTERNATIVES<br>CONSUMPTIVE USE | INSTREAM | COMBINATION | NO ACTION |
|---|---|---|---|---|---|---|---|
| Ekalaka | Little Beaver Creek/wells | Municipal | 20 | ▓ | ▓ | ▓ | |
| LB-061 | UT Little Beaver Creek | Irrigation | 90 | ▒ | | ▒ | |
| LB-063 | UT Little Beaver Creek | Irrigation | 14 | ▒ | | ▒ | |
| LB-083 | Bone Pile Creek | Irrigation | 75 | ▒ | | ▒ | |
| LB-141 | Mud Creek | Irrigation | 218 | ▒ | | ▒ | |
| LB-151 | UT Duck Creek | Irrigation | 114 | ▒ | | ▒ | |
| LB-181 | UT Dugout Creek | Irrigation | 17 | ▒ | | ▒ | |
| LB-182 | UT Dugout Creek | Irrigation | 38 | ▒ | | ▒ | |
| CT-041 | Little Beaver Creek | Irrigation | 195 | ▒ | | ▒ | |
| CT-071 | Little Beaver Creek | Irrigation | 186 | ▒ | ░ | ▒ | |
| CT-291 | UT Little Beaver Creek | Irrigation | 30 | ▒ | | ▒ | |
| CT-293 | UT Little Beaver Creek | Irrigation | 8 | ▒ | | ▒ | |
| CT-294 | Groundwater | Irrigation | 50 | ▒ | | | |
| CT-301 | Little Beaver Creek | Irrigation | 390 | ▒ | | | |
| CT-340 | HS Creek | Irrigation | 173 | ▒ | | ▒ | |
| DFWP | Little Beaver Creek | Instream | 17,895 | ░ | ▒ | ░ | |

▓ First priority of use

▒ Second priority of use

░ Third priority of use

☐ Not included in this alternative

a Instream flow requests that have been reduced to ½ the average annual flow

### Little Missouri subbasin–Beaver Creek Drainage

| APPLICANT/ PROJECT | SOURCE | TYPE OF RESERVATION | AMOUNT (af) | ALTERNATIVES<br>CONSUMPTIVE USE | INSTREAM | COMBINATION | NO ACTION |
|---|---|---|---|---|---|---|---|
| Wibaux | Beaver Creek/wells | Municipal | 70.6 | ■ | ■ | ■ | |
| WI-41 | UT Beaver Creek | Irrigation | 39 | ▨ | | | |
| WI-42 | UT Beaver Creek | Irrigation | 152 | ▨ | | | |
| WI-43 | UT Beaver Creek | Irrigation | 111 | ▨ | | ▨ | |
| WI-61 | UT Beaver Creek | Irrigation | 18 | ▨ | | | |
| WI-71 | UT Beaver Creek | Irrigation | 21 | ▨ | | ▨ | |
| WI-72 | UT Beaver Creek | Irrigation | 12 | ▨ | | | |
| WI-73 | E.F. Beaver Creek | Irrigation | 150 | ▨ | | | |
| WI-74 | E.F. Beaver Creek | Irrigation | 95 | ▨ | | | |
| WI-75 | UT Beaver Creek | Irrigation | 87 | ▨ | | | |
| WI-91 | Beaver Creek | Irrigation | 75 | ▨ | | | |
| WI-92 | Rattlesnake Creek | Irrigation | 78 | ▨ | | | |
| WI-93 | UT Beaver Creek | Irrigation | 9 | ▨ | | ▨ | |
| WI-121 | UT Beaver Creek | Irrigation | 41 | ▨ | | ▨ | |
| WI-151 | Yates Creek | Irrigation | 120 | ▨ | | | |
| WI-161 | UT Hay Creek | Irrigation | 33 | ▨ | | | |
| WI-162 | UT Yates Creek | Irrigation | 9 | ▨ | | | |
| WI-171 | Spring Creek | Irrigation | 38 | ▨ | | | |
| WI-181 | E.F. Beaver Creek and UT | Irrigation | 90 | ▨ | | | |
| WI-191 | UT Beaver Creek | Irrigation | 38 | ▨ | | | |
| WI-192 | UT Beaver Creek | Irrigation | 15 | ▨ | | | |
| WI-201 | Lamesteer Creek | Irrigation | 110 | ▨ | | ▨ | |

### Little Missouri subbasin–Beaver Creek Drainage (continued)

| APPLICANT/ PROJECT | SOURCE | TYPE OF RESERVATION | AMOUNT (af) | ALTERNATIVES<br>CONSUMPTIVE USE | INSTREAM | COMBINATION | NO ACTION |
|---|---|---|---|---|---|---|---|
| WI-202 | UT Lamesteer Creek | Irrigation | 66 | ▨ | | ▨ | |
| WI-211 | UT Beaver Creek | Irrigation | 44 | ▨ | | ▨ | |
| WI-221 | UT Lamesteer Creek | Irrigation | 11 | ▨ | | | |
| WI-232 | UT Beaver Creek | Irrigation | 32 | ▨ | | ▨ | |
| WI-233 | UT Beaver Creek | Irrigation | 29 | ▨ | | ▨ | |
| WI-234 | Lamesteer Creek | Irrigation | 98 | ▨ | | ▨ | |
| WI-235 | UT Beaver Creek | Irrigation | 39 | ▨ | | | |
| WI-236 | UT Beaver Creek | Irrigation | 59 | ▨ | | | |
| WI-237 | Duck Creek | Irrigation | 48 | ▨ | | | |
| LB-011 | Rattlesnake | Irrigation | 116 | ▨ | | | |
| LB-041 | Spring Creek | Irrigation | 24 | ▨ | | ▨ | |
| LB-121 | Beaver Creek | Irrigation | 146 | ▨ | | | |
| LB-161 | Fork of Beaver Creek | Irrigation | 408 | ▨ | | | |
| LB-171 | UT E.F. Beaver Creek | Irrigation | 45 | ▨ | | | |
| LB-172 | Beaver Creek and UT | Irrigation | 18 | ▨ | | ▨ | |
| LB-191 | Beaver Creek | Irrigation | 225 | ▨ | | | |
| DFWP | Beaver Creek | Instream | 7,984 | ░ | ■ | ░ | |

■ First priority of use

▨ Second priority of use

░ Third priority of use

☐ Not included in this alternative

a Instream flow requests that have been reduced to 1/2 the average annual flow

**Table 5-2.Proposed projects that would be reduced under the Instream or Combination alternatives**

| Project number | Proposed acreage | Instream Alternative acreage | Combination Alternative acreage |
|---|---|---|---|
| MC-01 | 214 | 129 | [a] |
| MC-06 | 298 | 140 | [a] |
| MC-09 | 342 | 304 | [a] |
| MC-99 | 934 | [b] | 824 |
| RI-03 | 810 | 376 | [a] |
| RI-05 | 526 | [b] | 300 |
| RI-06 | 416 | [b] | 167 |
| RI-09 | 935 | [b] | 658 |
| RI-10 | 643 | 374 | [a] |
| RI-11 | 686 | 343 | [a] |
| RI-12 | 782 | 431 | [a] |
| CBI-1 | 715 | [a] | 638 |
| CBI-2 | 1,065 | [b] | 996 |
| CBI-6 | 258 | [b] | 250 |
| CBI-10 | 770 | [b] | 690 |
| CBI-11 | 1,640 | [b] | 1,382 |
| CBI-14 | 291 | 273 | [a] |
| CBI-17 | 627 | 579 | 387 |
| CBI-19 | 549 | 469 | [a] |
| VA-01 | 75 | [b] | 22 |
| VA-03 | 933 | [b] | 792 |
| VA-231 | 320 | [b] | 201 |
| VA-261 | 157 | [b] | 77 |

[a] Project has not been reduced under this alternative
[b] Project not included in alternative

## ALTERNATIVES FOR THE SHERIDAN COUNTY GROUNDWATER AREA

Alternatives were developed specifically to address concerns raised by the Sheridan County Conservation District's application to reserve groundwater in Sheridan County. The complexity of the issues involving the aquifers in Sheridan County has necessitated this separate discussion of alternatives. A discussion of groundwater in Sheridan County is included in Chapter Four. These alternatives include the applications of the Sheridan County Conservation District and Plentywood.

### GRANT ALL ALTERNATIVE

Under this alternative, Plentywood's request would be granted in full with first priority. The Board also would grant the Sheridan County Conservation District the total amount of water it has requested for all proposed projects. The district would administer the reservation in accordance with the management plan in its application. A copy of the district's management plan is included in Appendix I. The amounts granted to the Sheridan County Conservation District would be as follows:

| Aquifer | Volume (af/yr) | Area that could be Irrigated (acres) |
|---|---|---|
| Westby-Dagmar outwash including Coalridge channels and recharge channels | 108,902 | 34,917 |
| Missouri River terrace gravels (preglacial Missouri River) | 12,510 | 3,997 |
| Tributary outwash | 7,924 | 2,532 |
| Big Muddy alluvium | 4,251 | 1,158 |
| **Total** | **133,587** | **42,604** |

### PARTIAL GRANTING ALTERNATIVE

Estimates of the amount of water available in the Westby-Dagmar and associated aquifers vary, based on recent groundwater studies. Under this alternative, the Board would grant the Sheridan County Conservation District a reservation for the amount of water DNRC believes the Westby-Dagmar and associated outwash aquifers can sustain without adverse effects to existing water right holders and wetlands. Because water shortages would continue to occur in the area during times of drought, the Board would condition the reservation so that only projects that are economically feasible when water is available 8 years out of 10 would be allowed to use the reserved water. The district would administer the reservation following the procedures outlined in its application. Plentywood's application would be granted in full with first priority. The amounts of water that would be granted to the Sheridan County Conservation District under this alternative for each aquifer are as follows:

| Aquifer | Amount (af/yr) | Approximate area that could be Irrigated (acres)[a] |
|---|---|---|
| Westby-Dagmar outwash including Coalridge channels and recharge channels | 1,509 | 482 |
| Missouri River terrace gravels (preglacial Missouri River) | 2,000 | 638 |
| Tributary outwash deposits | 2,000 | 638 |
| Big Muddy alluvium | 2,300 | 735 |
| **Total** | **7,809** | **2,493** |

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[a] Assumes an annual water requirement of 3.13 af per acre irrigated

## COORDINATED GROUNDWATER DEVELOPMENT ALTERNATIVE

The Sheridan County Conservation District would be granted a reservation for the maximum amount of water DNRC believes the Westby-Dagmar and associated aquifers can provide without harm to existing water right holders and wetlands. The water could be used on a first-come-first-served basis for any of the proposed projects. To help ensure that existing water right holders and wetlands would not be adversely affected, the Board would condition the reservation to have no force unless the area is declared a controlled groundwater area pursuant to 85-2-506 MCA. Under this alternative, Plentywood's application also would be granted with first priority.

Once the area is designated a controlled groundwater area, additional water development would for the most part be limited to the amount of water reserved to the conservation district, although some exceptions could be made for domestic and stock water use. Groundwater supervisors appointed by DNRC could oversee administration of the controlled groundwater area. These commissioners could include one representative each from the conservation district, U.S. Fish and Wildlife Service, Sheridan County Planning Department, Ducks Unlimited, a DNRC hydrogeologist, and an existing water user.

The supervisors would only approve a request to use reserved water if they find that: (1) there would be no substantial adverse effect to existing water right holders; (2) there would be no substantial adverse effect to wetlands; and (3) the water is suitable for irrigation, and irrigating with it would not damage soil productivity. The groundwater supervisors could specify monitoring or data collection needs or establish criteria on which to base permitting decisions. Test drilling and aquifer analysis would be required prior to development of irrigation wells to ensure that water is available in sufficient quantity and quality. Soils also would be analyzed to ensure that long-term soil productivity would not be damaged, given the quality of the water that would be used for irrigation.

The amounts of water granted to the district under this alternative by aquifer would be as follows:

| Aquifer | Amount (af/yr) | Approximate area that could be Irrigated (acres)[a] |
|---|---|---|
| Westby-Dagmar outwash including Coalridge channels and rechargechannels | 11,179 | 3,572 |
| Missouri River terrace gravels (preglacial Missouri River) | 2,000 | 639 |
| Tributary outwash deposits | 2,000 | 639 |
| Big Muddy alluvium | 2,300 | 735 |
| **Total** | **17,479** | **5,585** |

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a Assumes an annual water requirement of 3.13 af per acre irrigated

Designation of a controlled groundwater area in Sheridan County could be effective in regulating allocations and withdrawals of groundwater. Although the Board could condition the Sheridan County Conservation District's reservation on the designation of a controlled groundwater area, there is no certainty that it would be so designated. Creation of a controlled groundwater area requires at least 20, or one-fourth, of the groundwater users in an area to petition the Board for such a designation, or DNRC must propose the designation to the Board. The Board must then give public notice and hold a hearing. The findings of the hearing would determine if a controlled groundwater area is needed.

If a controlled groundwater area is not declared, the Board could reduce the amount to that specified under the Partial Granting Alternative, or deny the reservation request.

## NO ACTION/DENY ALTERNATIVE

The Board could deny all requested reservations. In Chapter Six, DNRC describes trends that might occur through the year 2025 if no water is reserved for any purpose.

## CONSIDERATIONS COMMON TO ALL ALTERNATIVES

DNRC defined certain commonalities that would apply to all the alternatives.

1. Reservations must adhere to the statute requiring that instream reservations not exceed one-half the average recorded annual flow on gauged streams. Reservation requests in excess of this statutory limit were reduced to legal levels.
2. The concentration of arsenic in the Milk and Missouri rivers far exceeds the state instream water quality standard (discussed in Chapter Four). Consumptive use projects could violate this standard. However, DNRC did not exclude any projects from discussion on the basis of arsenic problems. If the Board grants consumptive use reservations that could cause violation of the instream arsenic standard, it could require that the projects involved be subject to compliance with certain conditions such as the following:
    a. Could require reservants to demonstrate that their projects would not violate water quality standards. This finding could be required for each project before it could be developed.
    b. Construction of water treatment facilities or other actions could be required to reduce arsenic contamination to compensate for any increased arsenic concentrations caused by the new consumptive uses.
3. Each reservant could be required to install a water-measuring device. This could assist in managing water allocated for reservations.

## CHAPTER SIX

# IMPACTS

## INTRODUCTION

In this chapter, the environmental effects that would result from each alternative presented in Chapter Five are analyzed. DNRC used environmental checklists, results of the Missouri River Water Availability model, observations from field investigations, and other information cited in the text in developing this chapter.

The reservation rules require the applicants to submit only reconnaissance level project designs and development schedules, so specific details necessary to analyze environmental effects thoroughly were unavailable for some projects. This is especially true for the larger irrigation projects, such as project CBI-13, and the Battle Creek Dam project (BL-181), which are included in the Consumptive Use Alternative. To comply with MEPA, additional environmental review may be required before large projects can be developed and, in some cases, this may involve the preparation of a project-specific EIS. The Board may require DNRC to conduct a separate environmental review or conduct a joint environmental review with other state and federal agencies having jurisdiction over project development (ARM 36.2.522) before a project can be developed.

When assessing the impacts of the alternatives, DNRC assumed that instream flow reservations would take effect immediately, and that all water reserved for irrigation and municipal use would be in use by the year 2025.

About 75 percent of the water the Board reserved for applicants in the upper Missouri River basin reservation proceeding is not subject to the basin closures discussed in Chapter Two and the closures are not permanent. Calculations of the effects of lower Missouri River basin reservations begin with the assumption that all water the Board reserved for applicants in the basin above Fort Peck Dam would be fully used. Upper Missouri River basin reservations would alter streamflows in the Milk River and the Missouri River below Fort Peck Dam. These streamflow alterations could affect fisheries, wildlife, and recreational resources along these streams.

Although a reservation for BUREC's proposed Virgelle Diversion project was granted in the upper Missouri River basin water reservation proceeding, it is not certain that the project will be developed. Before the project could be built, Congress would have to approve and fund it, and the project would also need to comply with the National Environmental Policy Act. For the Consumptive Use, Combination, and Instream alternatives, DNRC assumed flows in the Milk River basin would be augmented by the Virgelle Diversion project. This masks the impacts of lower basin projects on Milk River flows, and even increases streamflows above present levels in much of the Milk River. In its impact analysis, DNRC also analyzed a scenario in which all the requested reservations would be granted, but the Virgelle Diversion project would not be developed.

## WATER QUANTITY AND DISTRIBUTION

The use of additional water for irrigation and municipal reservations would alter streamflows and groundwater levels. Instream flow reservations would not directly affect the existing water quantity or distribution, but could have indirect effects. The following paragraphs identify general ways in which the quantity and distribution of water in streams and reservoirs would be affected by the proposed reservations under the alternatives.

Much of the water diverted for irrigation evaporates or is consumed by plants. Excess water applied to crops returns to a stream as surface runoff or seeps into the ground and moves downward to the water table. In instances where a stream and water table are connected, this water may, over time, return to the stream. Water that leaks from canals also may return to a stream. Excess water that is diverted for irrigation and eventually discharges to a stream, either via surface water or groundwater, is referred to as irrigation return flow.

Most of the new irrigation projects proposed by the conservation districts would use efficient sprinkler systems, and return flows would be small. Model results show that return flows from the proposed full service irrigation projects would lessen impacts of irrigation withdrawals during the summer and early fall, and might slightly increase streamflows during the winter. Return flows from water-spreading projects in particular can increase late summer streamflows. Generally, water is diverted for water spreading only during the spring runoff. Much of the water that is not used by crops accumulates underground and appears later as groundwater return flows.

Some of the water diverted for municipal use will be lost to evaporation or consumed, primarily by lawns and gardens. Most water used for household purposes will pass through wastewater treatment facilities and then return to a stream or shallow aquifer. Water also can enter the ground from leaky city distribution systems and eventually return to a stream or aquifer.

## TERMINOLOGY AND CONCEPTS

When estimating how different alternatives would affect flows in the lower Missouri and Milk rivers, streamflow alterations due to upper Missouri River basin reservations also are factored in. Streamflows that occur under existing conditions (no upper or lower Missouri River basin reservations) are referred to as "baseline" flows.

Throughout this chapter, references are made to "wet," "typical," and "dry" years. Wet years have average monthly flows that are exceeded in only 2 out of 10 years. These wet year flows are also referred to as the 20th percentile exceedance flows. Similarly, dry years have average monthly flows that are typically exceeded 8 out of 10 years. Dry year flows are referred to as 80th percentile exceedance flows. Typical years have flows that are exceeded 5 out of 10 years. They also are referred to as median, or 50th percentile exceedance flows.

### LOWER MISSOURI RIVER SUBBASIN

**Missouri River:** The effects of the water reservations on streamflows in the Missouri River generally would be small, and most reductions are attributable to reservations that were granted in the upper Missouri River basin water reservation proceeding. For the Consumptive Use Alternative, the average annual depletions for the Missouri River immediately below Fort Peck Dam would be 207 cfs (Figure 6-1), or approximately 2.4 percent of the average annual flow. Streamflow depletions would be even less under the Combination and Instream alternatives (Figure 6-1). As can be seen by the lack of difference between the Consumptive and the No Action alternatives in Figure 6-1 and Appendix D, over 90 percent (190 cfs) of these depletions can be attributed to the upper basin reservations and would exist under the No Action Alternative.

Between Fort Peck Dam and Wolf Point (Figure 6-2), water would be diverted for an additional 8,656 acres of new irrigation under the Consumptive Use Alternative, but this withdrawal would be offset by return flows from the Virgelle Diversion, reducing the net average annual depletion from 207 cfs below Fort Peck Dam to 198 cfs at Wolf Point. The average annual depletion increases to 268 cfs between Wolf Point and the Montana/North Dakota state line (Figure 6-3) as 38,162 acres of new irrigation are added under the Consumptive Use Alternative along the Missouri and Poplar rivers. Impacts would be smaller under the Combination Alternative, and much less under the Instream Alternative (Appendix D).

**Missouri River Tributaries:** The only consumptive use reservation request in the Redwater River drainage is Circle's municipal well application. The depth of the well (1,600 feet into the Fox Hills Sandstone), and the small quantity of the requested reservation (78 af/yr) would cause immeasurably small depletions in the Redwater River (less than 0.1 cfs) (Appendix D). Return flows to the Redwater River also would be immeasurably small.

In the Poplar River drainage, 1,414 acres of new irrigation are included in the Consumptive Use Alternative. The largest average monthly depletion would be 5 cfs on the Poplar River during June under the Consumptive Use Alternative, equal to 7 percent of the average monthly flow (Figure 6-4 and Appendix D). Local effects would be larger on certain tributaries, as summarized in the Fisheries Impacts section. Water-spreading projects would deplete spring flows to a small degree on the Poplar River, and to a larger degree on some small tributaries. Return flows from spring diversions for water-spreading projects would slightly lessen the impacts of full service irrigation projects during the summer. Impacts would be smaller under the other alternatives.

**Figure 6-1. Computed streamflows in the Missouri River below Fort Peck Reservoir under each alternative**

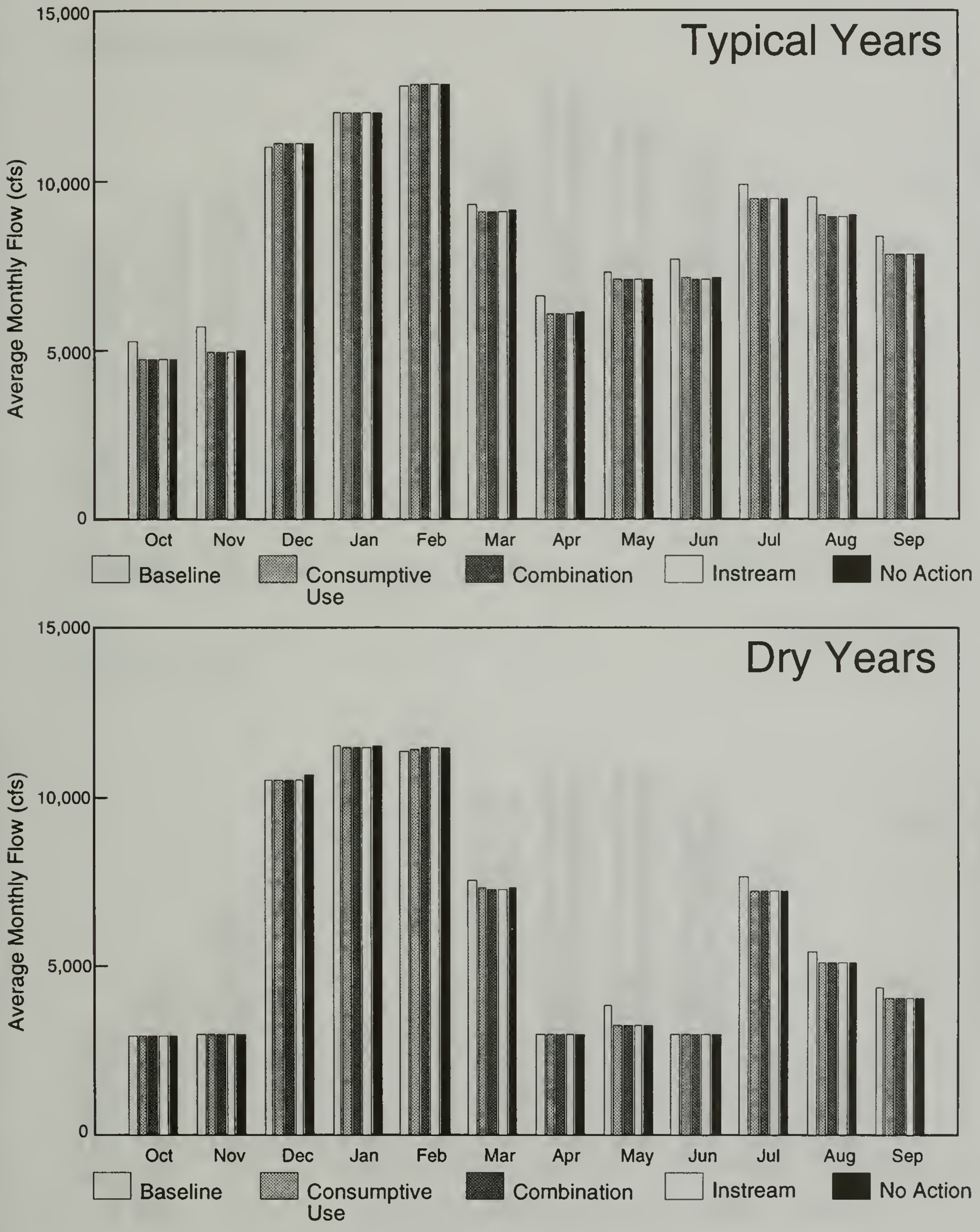
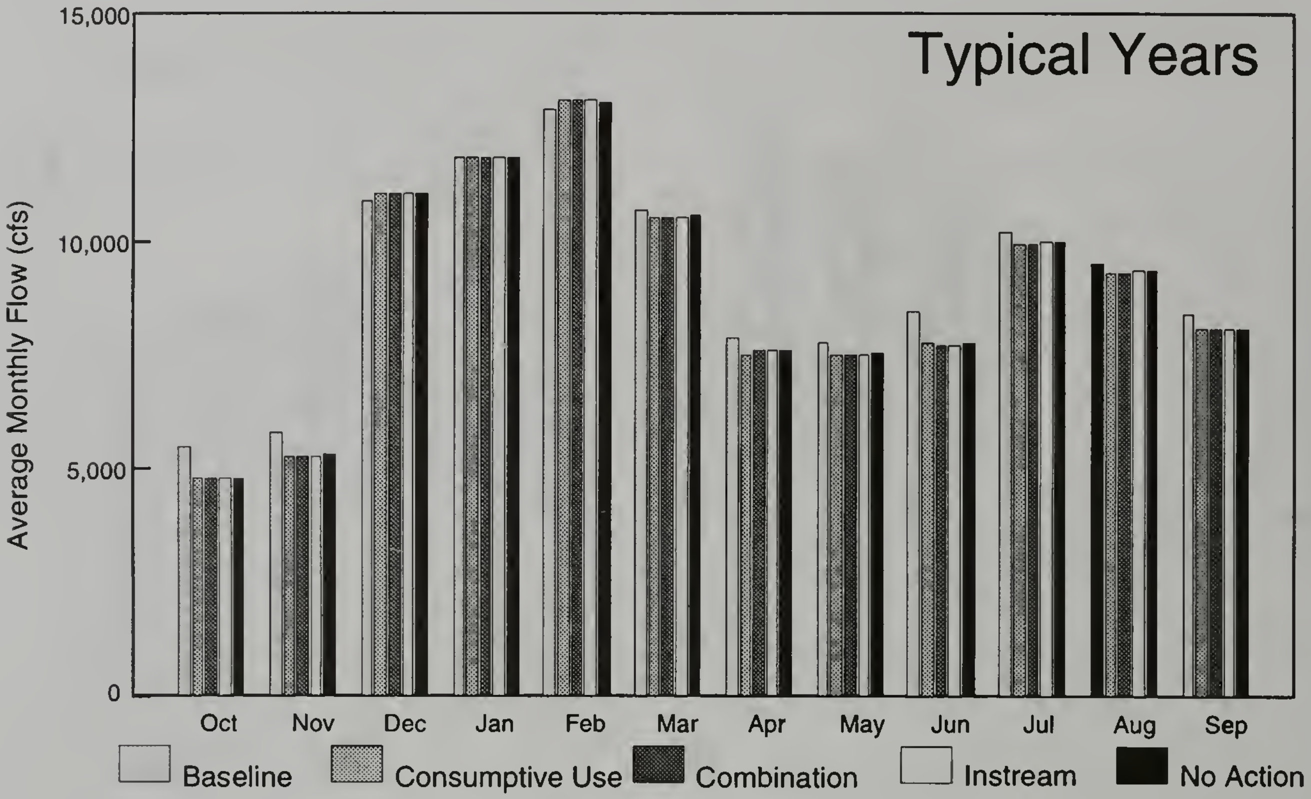


**Figure 6-2. Computed streamflows in the Missouri River near Wolf Point under each alternative**



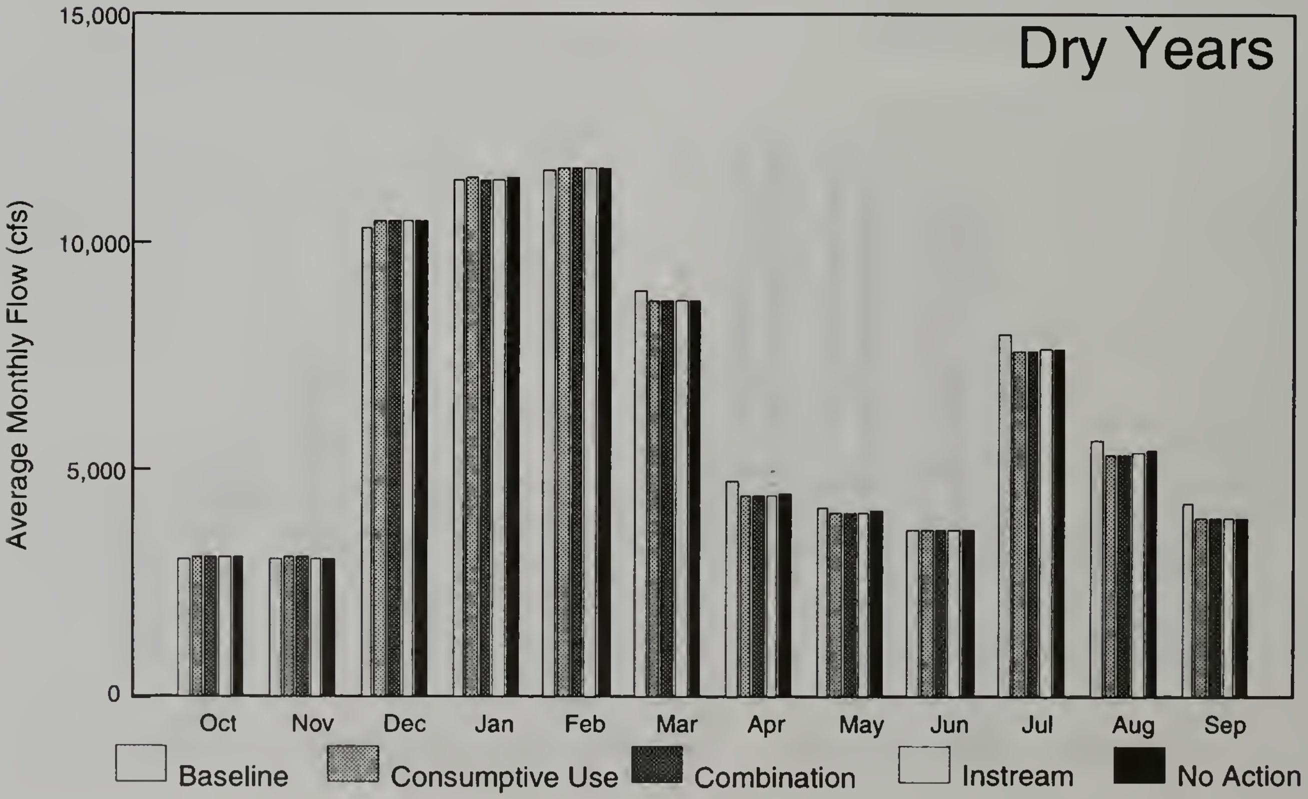


**Figure 6-3. Computed streamflows in the Missouri River at the North Dakota state-line under each alternative**

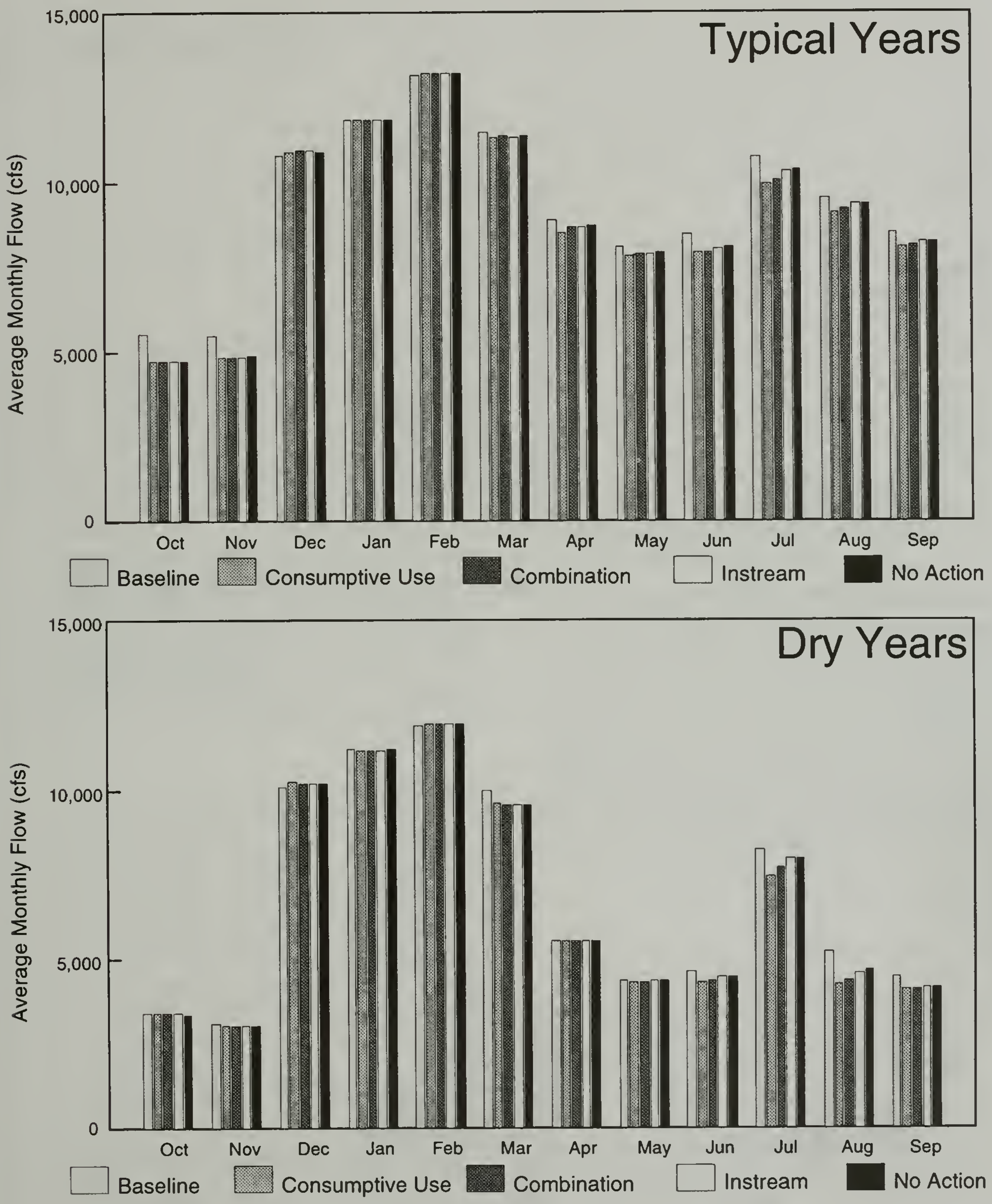
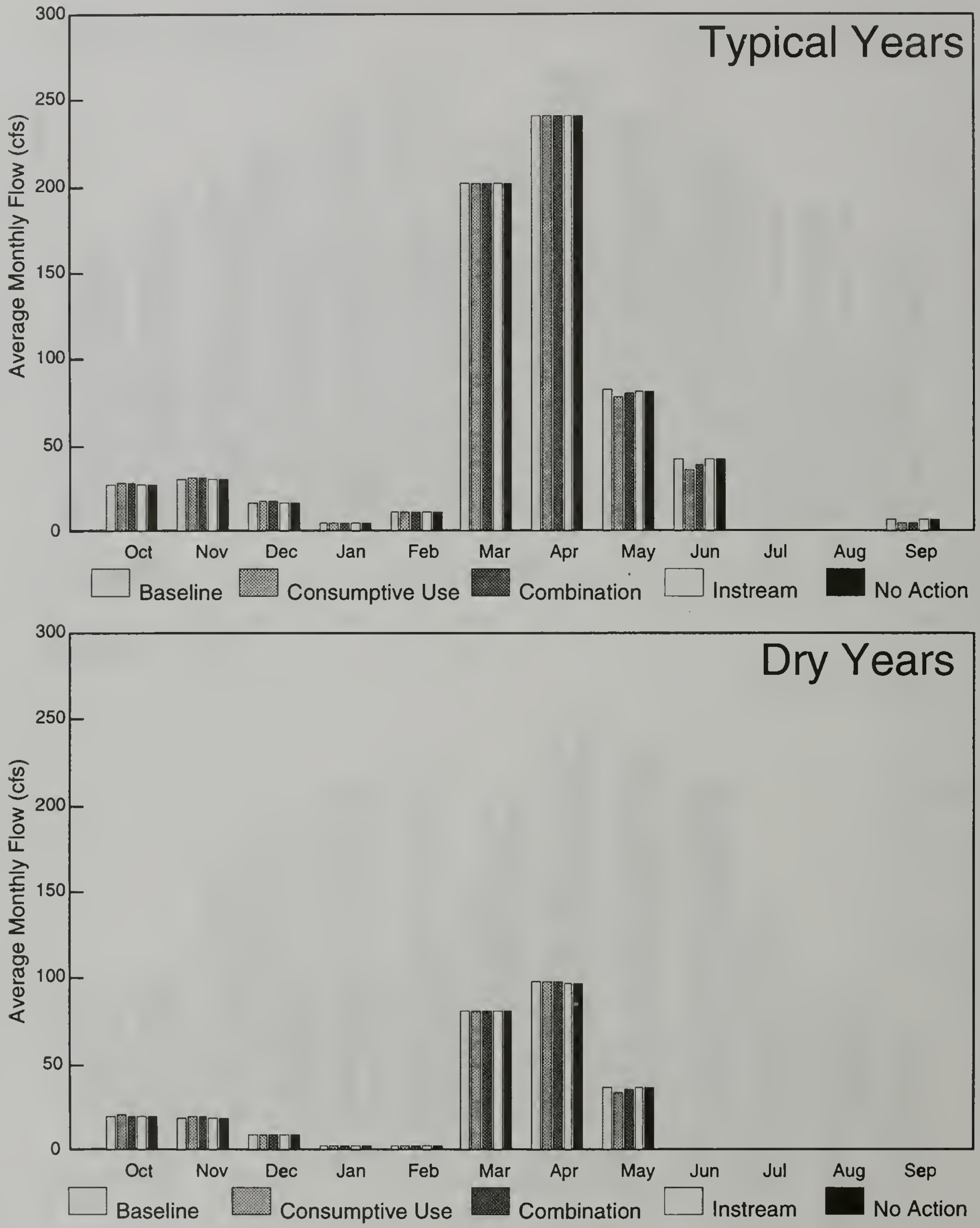


**Figure 6-4. Computed streamflows in Poplar River at mouth under each alternative**



### MILK RIVER SUBBASIN

**Milk River:** In the upper Missouri River water reservation proceeding, the U.S. Bureau of Reclamation was granted a reservation for 230 cfs to be diverted from the Missouri River to the Milk River through the proposed Virgelle Diversion. When this diversion is included in an analysis of streamflows in the Milk River, the additional flows tend to mask most impacts resulting from the proposed projects in the Milk River subbasin (Figure 6-5 and Appendix D). Since most of the flow of the Milk River is typically diverted near Dodson during the irrigation season and would continue to be if the Virgelle Diversion is built, the Virgelle Diversion would have a lesser effect below Dodson.

The Virgelle Diversion tends to lessen the annual variability in streamflows by supplying water during dry years. The influence of the Virgelle Diversion may be best illustrated at the Milk River near Harlem (Figure 6-8 and Appendix D). The difference between a wet and a dry June without the diversion is 654 cfs, while the difference between a wet and a dry June with the diversion is only 284 cfs.

Under any of the action alternatives, municipal diversions do not have a particularly large effect on streamflows in the Milk River because diverted quantities are typically low and return flow rates are high. A total of 2,128 acre-feet of new municipal diversions could occur in the Milk River subbasin under the Consumptive Use Alternative, but only a small percentage would be permanently removed from the drainage.

Below the Dodson diversion dam, flows in the Milk River are primarily due to return flows and tributary inflow during most years. The Virgelle Diversion would increase return flows from upstream irrigation (Figure 6-6). For example, August flows in the Milk River at Nashua would increase 28 percent above the baseline under the Combination Alternative (Figure 6-7). Enough water to irrigate 783 acres would be diverted from the Milk River between Dodson and Nashua under the Consumptive Use Alternative.

The largest effect from requested water reservations in the upper portion of the Milk River subbasin would result from project BL-181, an 18,593-acre-foot storage project on Battle Creek. High spring flows would be stored in this reservoir for later use by irrigators downstream on Battle Creek and on the Milk River. The effects on streamflows would be most marked on Battle Creek. Typical spring flows in Battle Creek would be reduced 30 to 50 percent, while typical summer flows would increase two to nine fold (Figure 6-8 and Appendix D). In dry years, the reservoir would not store as much in the spring and its influence on Battle Creek streamflows would be less, although typically there still would be some flow augmentation in the summer. The effects of project BL-181 on the Milk River would be similar to effects on Battle Creek, but more subdued due to the larger flow volume in the Milk River. This project is included only in the Consumptive Use Alternative.

The upper portion of the Milk River subbasin has three other irrigation/storage projects—BL-131, BL-171, and LI-241. These three small projects would irrigate 191 acres. The impact to streamflow from BL-171 and LI-241 would be primarily limited to the spring when they would store runoff. There also would be some small amount of flow augmentation later in the summer from return flows. Project BL-131 would capture most flows from a small spring in an unnamed tributary of Black Coulee. The project would deplete streamflow below the spring year-round, although depletions would be less just after the irrigation season when return flows from irrigation would augment streamflows.

If the Canadians consume their entire allotted share of water in Battle Creek, streamflows would not decrease much on Battle Creek during most months (Figure 6-8) because the Canadians already take most of their allocated share of water. Full development of Battle Creek water by the Canadians would leave less water available for storage in the proposed Battle Creek Reservoir than was anticipated when the application was developed. Consequently, further analysis of water availability for the reservoir should be examined prior to construction.

**Figure 6-5. Computed streamflows for the Milk River near Harlem under the Consumptive Use Alternative both with and without the proposed Virgelle diversion**

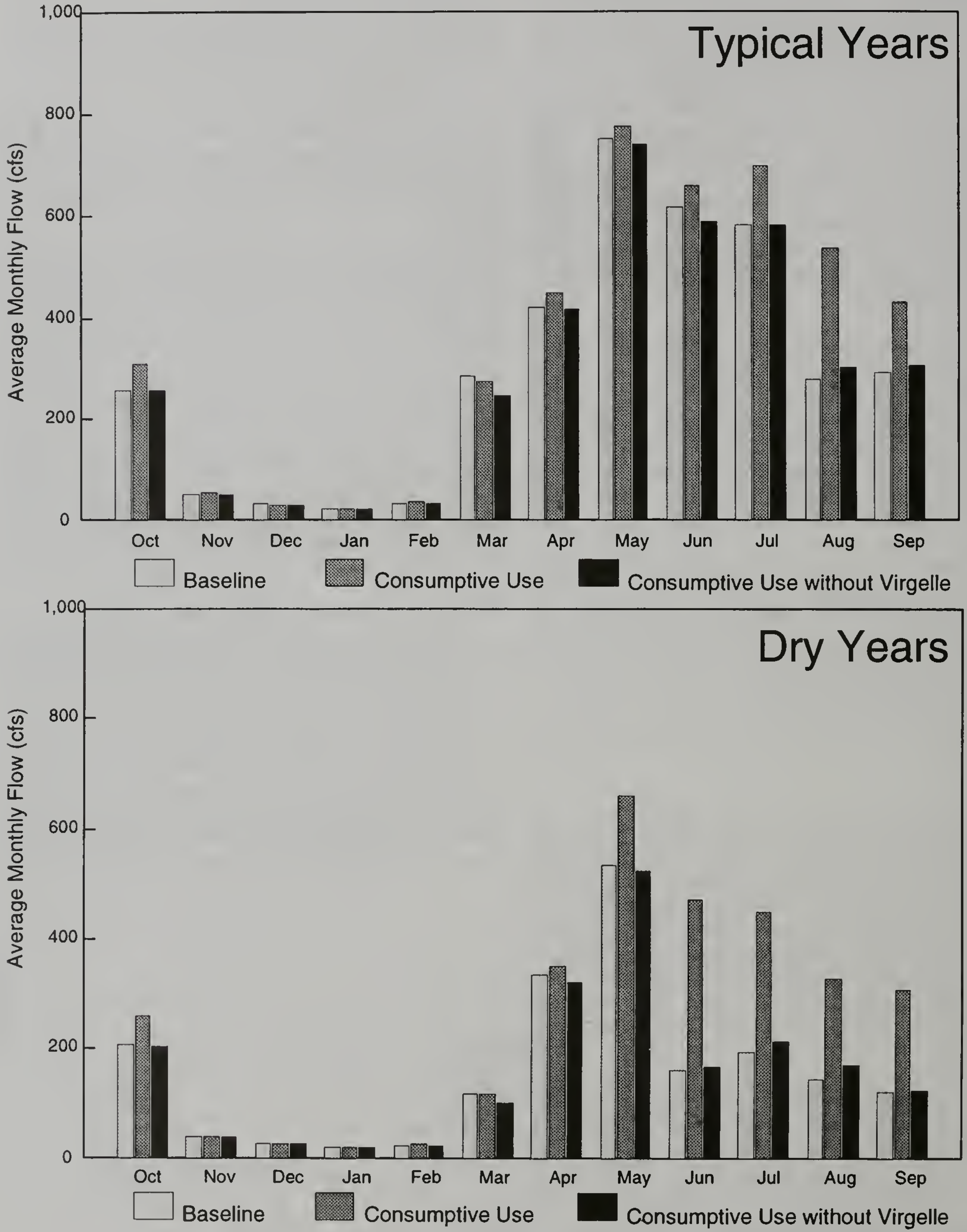


**Figure 6-6. Computed streamflows in Milk River at Dodson under each alternative**

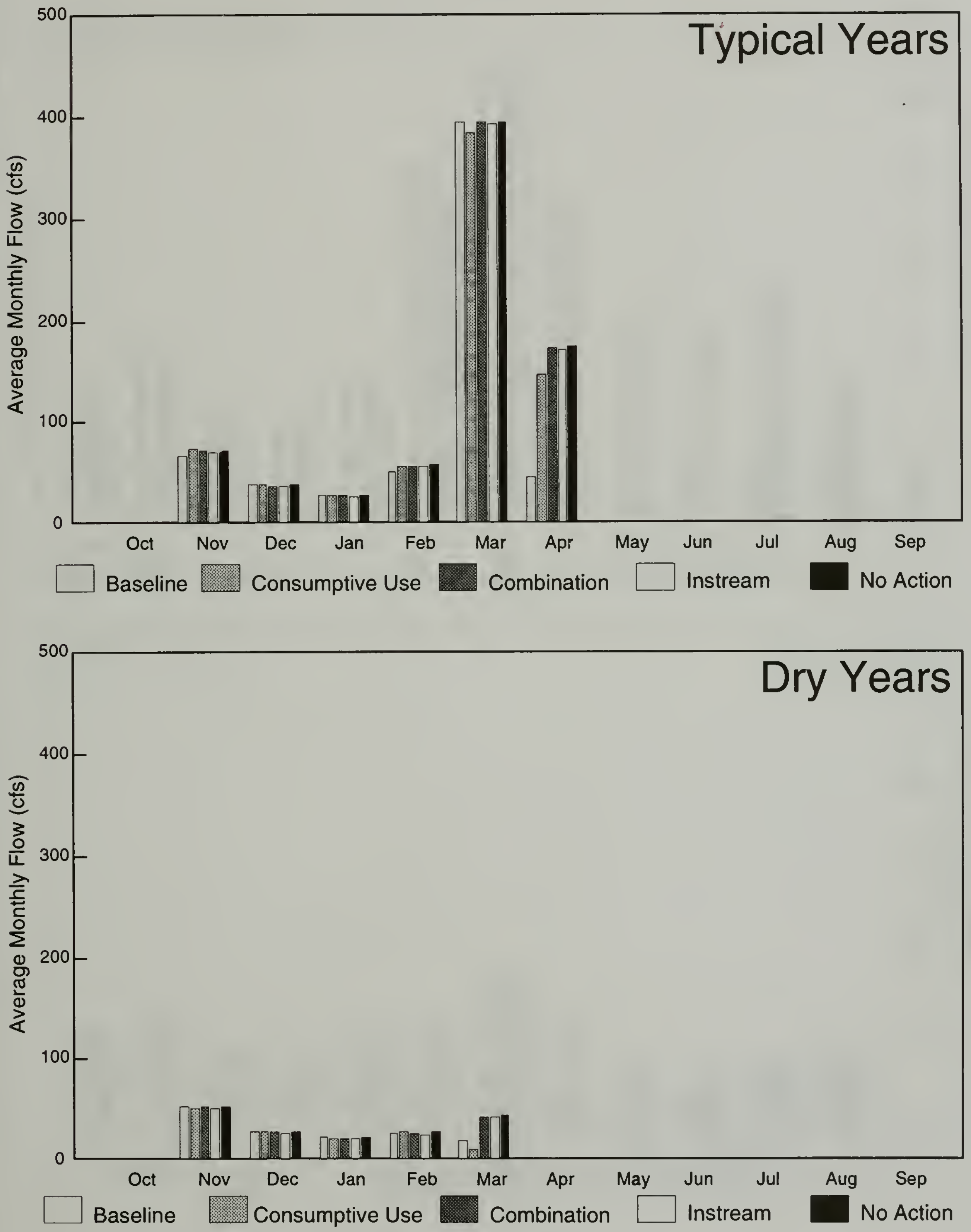


**Figure 6-7. Computed streamflows in the Milk River near Nashua under each alternative**

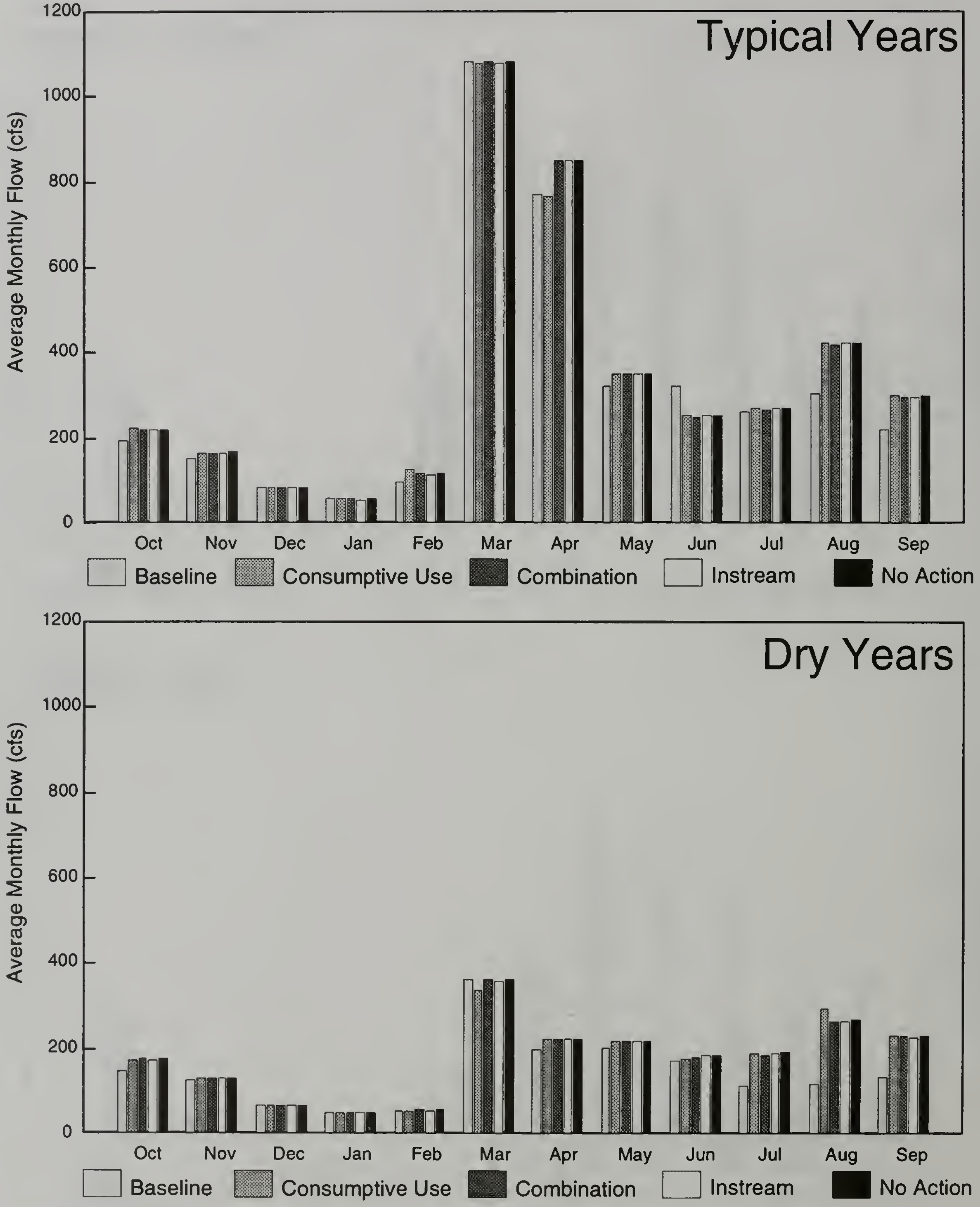
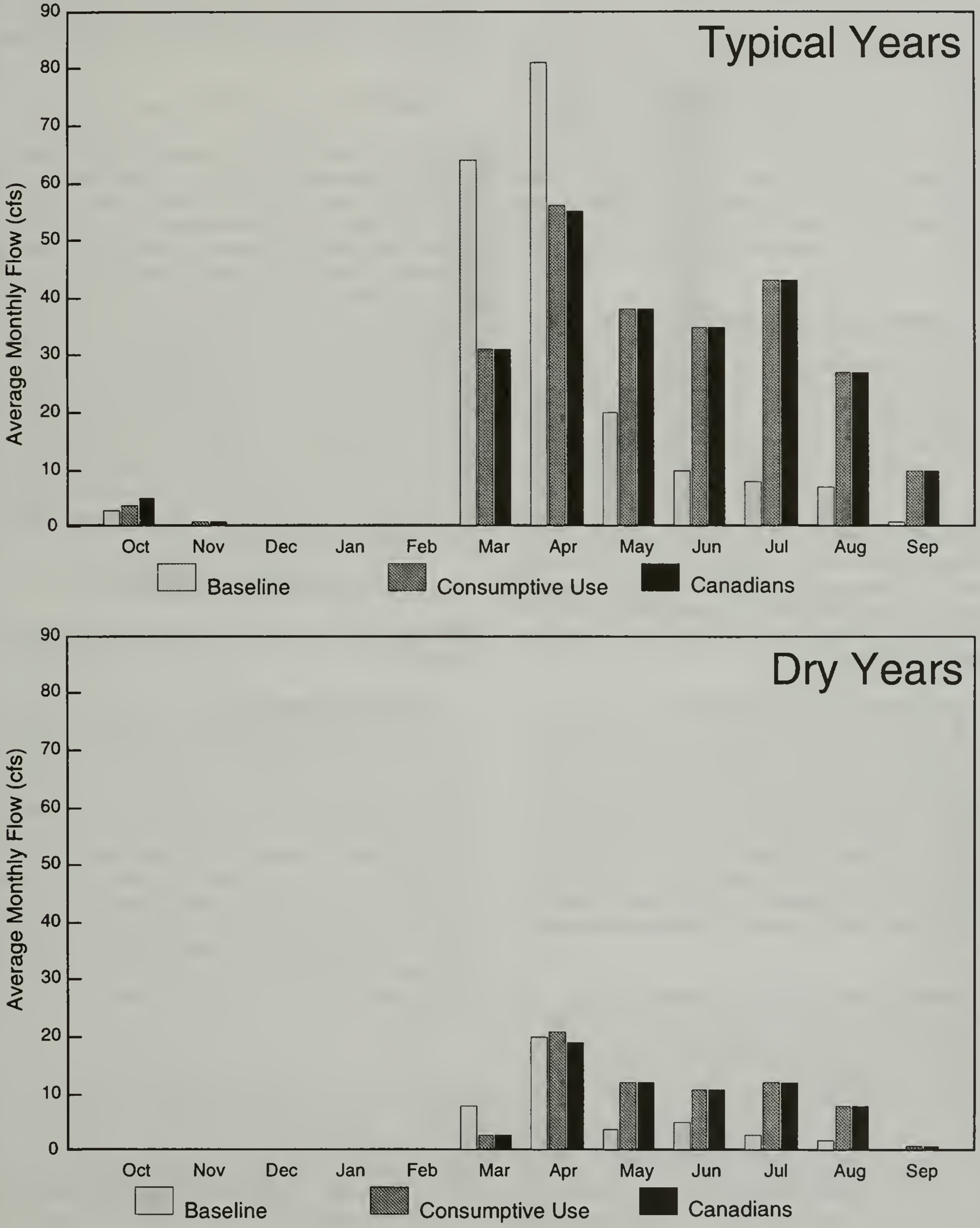


**Figure 6-8. Computed streamflows in Battle Creek at its mouth under the Consumptive Use Alternative**



### LITTLE MISSOURI RIVER SUBBASIN

**Little Missouri River Drainage:** Average annual flows in the Little Missouri River would be reduced by approximately 1 percent under the Consumptive Use Alternative, with depletions concentrated in the summer (Figure 6-9). The most serious effects would occur in August during dry years when already low flows (3.6 cfs) would be lowered 92 percent to 0.3 cfs (Appendix D). During typical years, August flows would decrease 16 percent from 16.2 to 13.6 cfs. The water-spreading projects in this drainage would tend to reduce the spring runoff peak and augment summer flows with return flows (Appendix D).

**Boxelder Creek Drainage:** Average annual flows in Boxelder Creek would be depleted 1.5 percent under the Consumptive Use Alternative (Figure 6-10). Depletions would be concentrated in the summer with the most severe effects during August. During dry years, the present average August flows of 2.9 cfs would be dried up. During typical years, flow reductions of 22 percent would lower August flows from 11.8 cfs to 9.2 cfs. Water-spreading projects would tend to redistribute some of the peak springtime flows to later months, thereby offsetting some of the summertime impacts from full service irrigation. Impacts would be slightly less under the Combination Alternative and much less under the Instream Alternative.

**Little Beaver Creek Drainage:** The large number of water-spreading projects in the Little Beaver Creek drainage would concentrate flow depletions in the spring, especially during March and June of typical or wet years (Figure 6-11 and Appendix D). Depletions during other months and during dry years would be minimal. Depletions would be largest under the Consumptive Use Alternative (up to 17 percent in March), less under the Combination Alternative, and practically nonexistent under the Instream Alternative.

**Beaver Creek:** Water-spreading projects on Beaver Creek and its tributaries would reduce streamflows during the spring (Figure 6-12 and Appendix D). March is the peak flow month and would have correspondingly high depletions under the Consumptive Use Alternative (29 percent depletion from 70 cfs to 50 cfs). During July and August, return flows would augment streamflows slightly. During dry years, the March flows would be reduced 40 percent from 13.9 cfs to 8.3 cfs. Impacts would be less severe under the Combination Alternative. There would be no impacts under the Instream Alternative.

**Other:** Projects LB-181 and LB-182 are both located on an unnamed tributary of Dugout Creek, an intermittent stream that flows across the North Dakota state line into the Little Missouri River. These projects would slightly reduce spring runoff in Dugout Creek.

### SHERIDAN COUNTY GROUNDWATER AREA

The Big Muddy Creek drainage is hydrologically complex. Interactions between surface water and groundwater are not well understood, and diversions from Big Muddy Creek into Medicine Lake by USFWS further complicate the system. Aquifer depletions by irrigation projects in Sheridan County would lower reservoir levels in Medicine Lake, and might slow discharge rates from the Westby-Dagmar aquifer into the Big Muddy Creek alluvial aquifer. Streamflows in the lower portion of Big Muddy Creek and the Missouri River downstream are likely to be depleted both by additional diversions necessary to raise the level of Medicine Lake and by lower recharge rates into the Big Muddy Creek alluvial aquifer. This effect would be greatest under the Sheridan County Groundwater Area Grant All Alternative, and much less under the other alternatives.

## GROUNDWATER

### SHERIDAN COUNTY GROUNDWATER AREA

**General Considerations:** A variety of factors makes groundwater far more complicated to manage than surface water. Hydrologists evaluate groundwater by measurements, such as water levels in wells, pumping tests, and analysis of water samples and sediments from boreholes. Water level measurements are used to determine the direction of groundwater flow. Pumping tests and sediments from boreholes provide information used to determine extent and physical characteristics of an aquifer. The chemistry of water samples from wells reflects the age and movement of groundwater and can be used in identifying groundwater sources and determining flow directions.

Unlike a river which flows in a well-defined channel, an aquifer commonly underlies a vast area, and the amount of water that circulates through the aquifer cannot generally be measured accurately. Impacts resulting from a groundwater diversion or a withdrawal may be manifested over a large area and a long time, making them difficult to measure or assess.

**Figure 6-9. Computed streamflows in the Little Missouri River under each alternative**

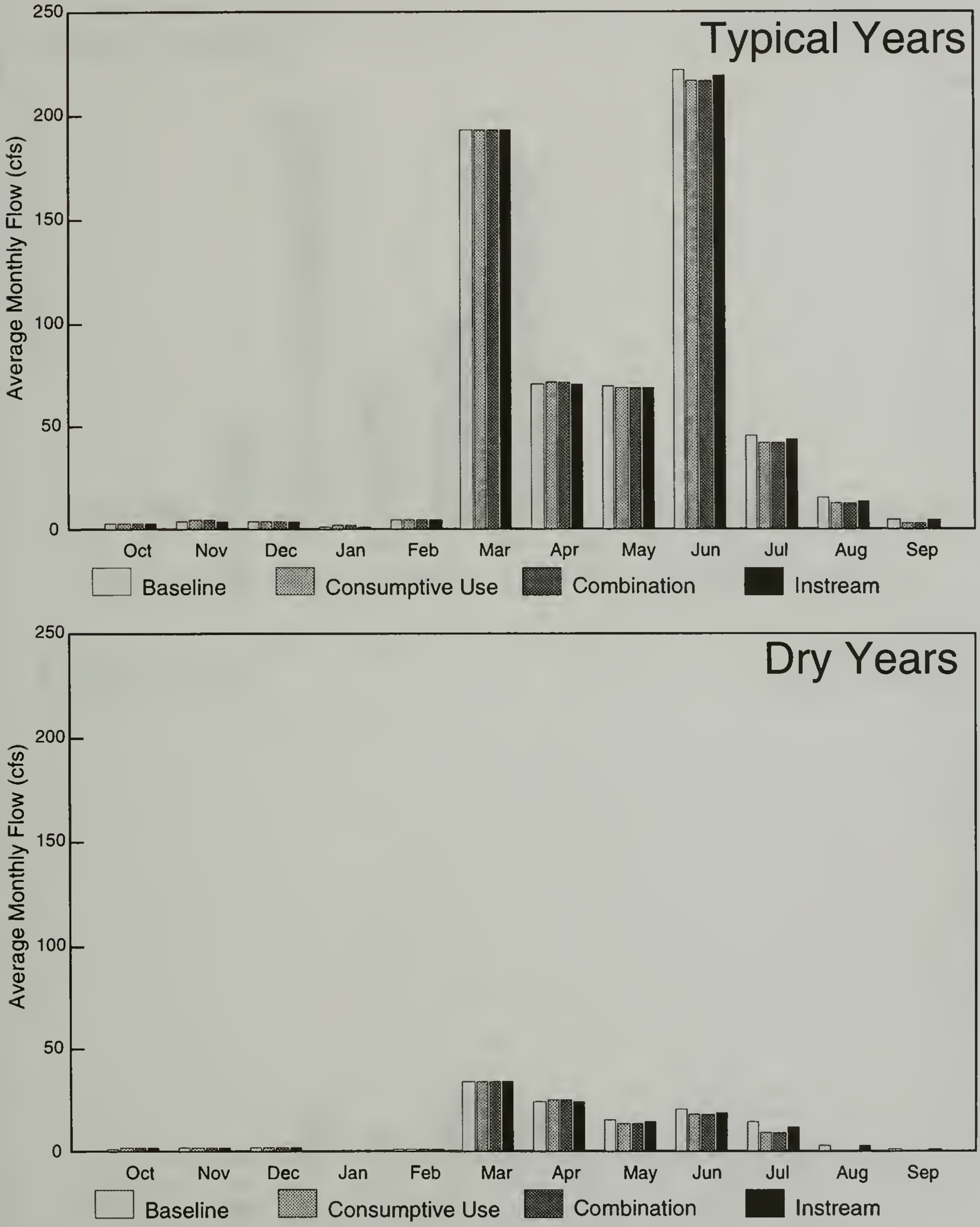
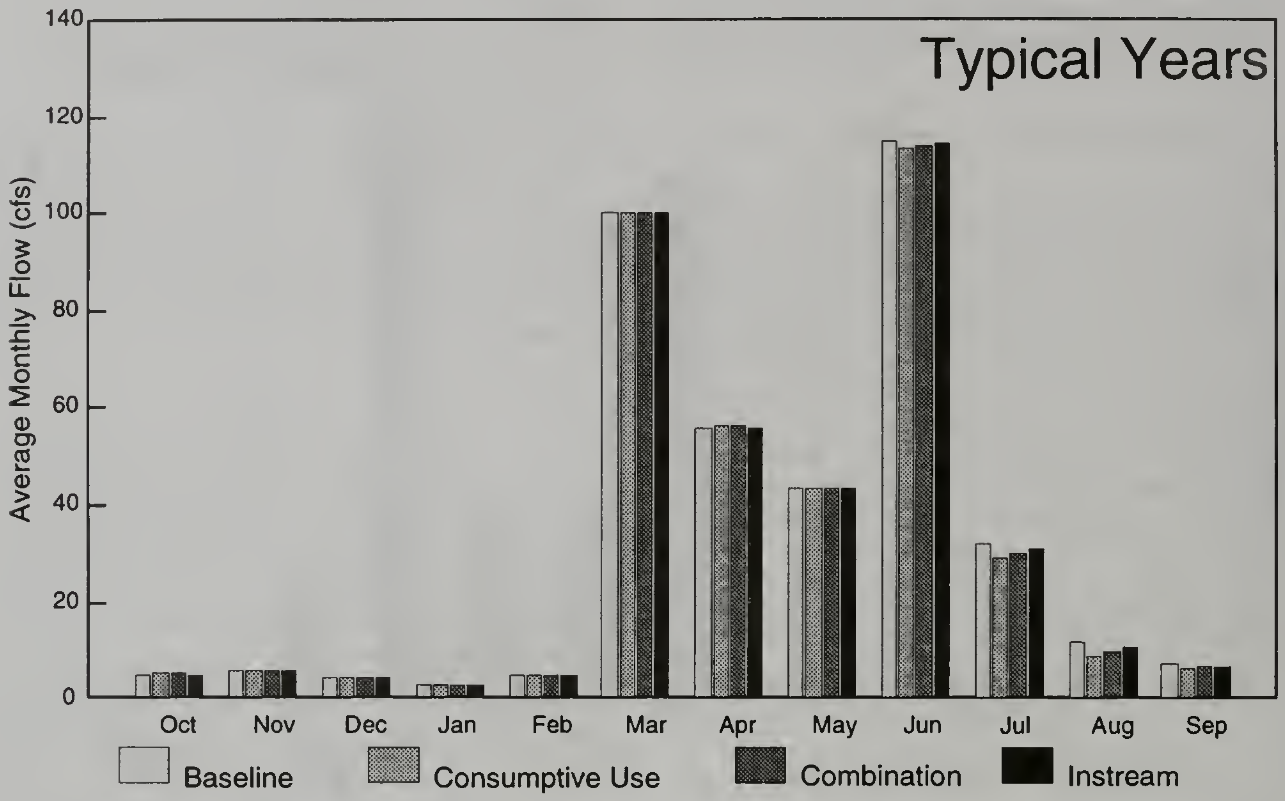


**Figure 6-10. Computed streamflows in the Boxelder Creek under each alternative**



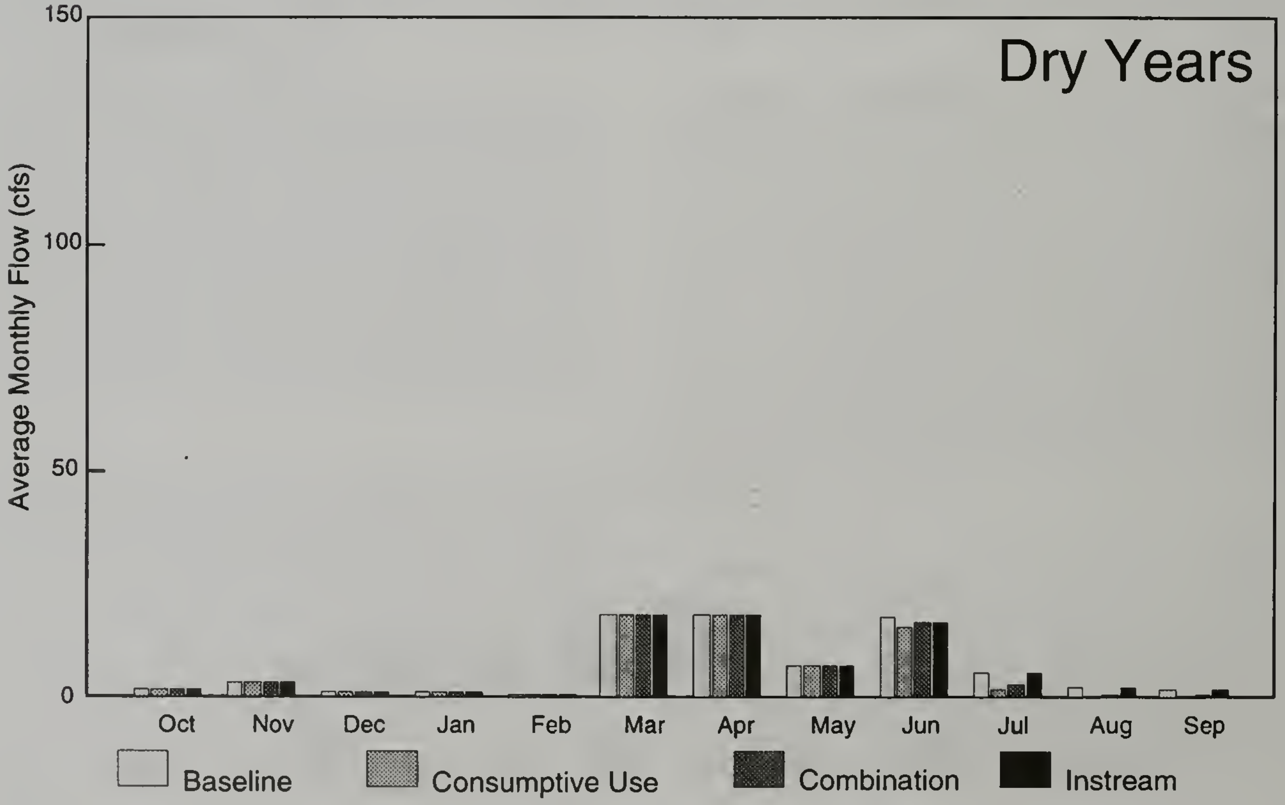


**Figure 6-11. Computed streamflows in Little Beaver Creek under each alternative**

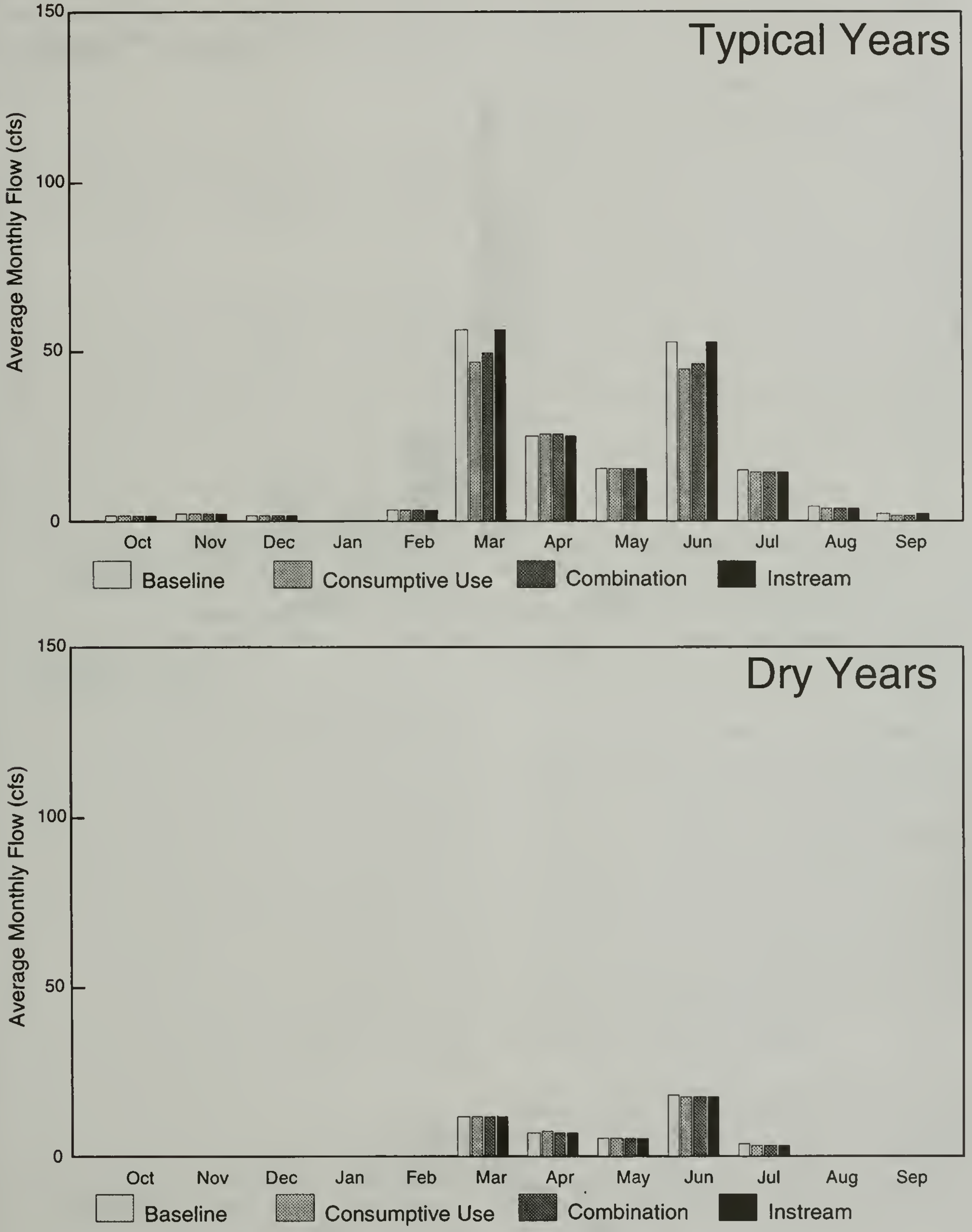
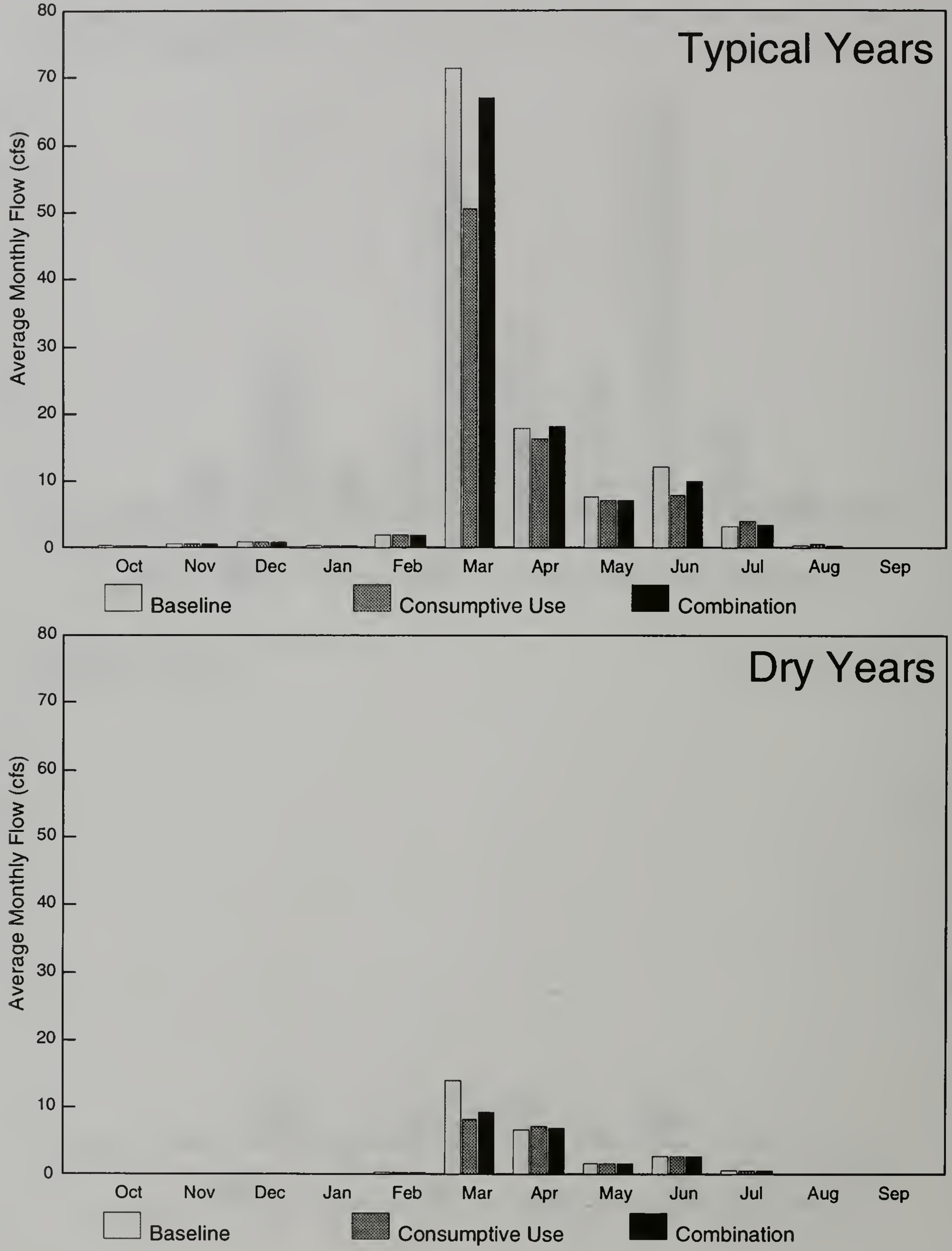


Figure 6-12. Computed streamflows in Beaver Creek under each alternative



Despite these difficulties, successful groundwater management schemes have been devised in many parts of the United States. Typically, such management encompasses entire groundwater basins, and interrelationships between surface water and groundwater are determined through hydrologic studies.

Perhaps the most pressing question surrounding the Sheridan County Conservation District's application for a reserved water right is: "How much water is available?" Unfortunately, a single value cannot be provided for available water.

In the Sheridan County Conservation District's application, the sustainable yield of an aquifer is defined as "the yield available without long-term mining of groundwater in storage." Donovan (1988) uses the same definition, adding "that is, an amount that can be offset by long-term annual recharge." This definition is vague and oversimplifies the concept of sustained yield. It has been shown that a groundwater basin can actually yield more water than it normally receives through additional recharging induced by withdrawal, and through the elimination of discharges (Freeze and Cherry 1979). Furthermore, the definition includes no mention of possible impacts of lowering water levels in the system such as drying up lakes and wetlands or causing an influx of poor quality water from surrounding bedrock aquifers.

Fetter (1980) defines the safe yield of an aquifer as "the amount of naturally occurring groundwater that can be withdrawn from an aquifer on a sustained basis, economically and legally, without impairing the native groundwater quality or creating an undesired effect such as environmental damage." Freeze and Cherry (1979) provide a similar definition and discuss the widespread dissatisfaction with the term "safe yield" even among groundwater experts. They discuss another term, "optimal yield." Optimal yield includes consideration of a variety of social and economic objectives associated with the uses to which the water is to be put. Depending on the situation, optimal yield could involve mining groundwater, even to the point of depletion, or it could require complete conservation, but most often lies somewhere between these extremes.

Thus, determining an appropriate "sustainable yield" can be difficult. It must be determined with a variety of information and must encompass the overall objectives of many water users. In California, where groundwater basins are managed by local water users, safe yields sometimes are recalculated in response to changed circumstances in the basins. This flexibility has some advantages over other approaches such as a one-time evaluation of safe yield determined by courts or a state agency.

**Estimates of Available Groundwater:** Estimates of the amount of groundwater that could be extracted from the Westby-Dagmar aquifer on sustainable basis range from 6,330 af/yr (Donovan 1988) to 16,000 af/yr (Gallagher 1991). Average annual withdrawals of groundwater are estimated to be about 4,821 af/yr in 1988 (Donovan 1988). This reduces the estimated remaining available groundwater in the Westby-Dagmar outwash, Coalridge channels, and recharge channels to a level between 1,500 and 11,100 af/yr. Little information is available upon which to base estimates of groundwater availability from tributary outwash deposits, Missouri River terrace gravels (preglacial Missouri River), and the Big Muddy Creek channels. DNRC estimates that a total of some 6,300 af/yr may be available from these aquifers. Table 6-1 summarizes the estimates of groundwater availability.

The estimates of sustainable yield from the Westby-Dagmar aquifer are uncertain. Donovan (1988) explains that the sustainable yield estimated using a groundwater model could range from zero to twice the estimated value if recharge or discharge of the aquifer is underestimated or overestimated as little as 12 percent.

**Impacts of Groundwater Development:** Impacts resulting from pumping wells may occur in the immediate vicinity of the wells as a result of reduced water levels or aquifer pressure or they may occur elsewhere in the aquifer system or its components. Impacts in the well vicinity usually can be measured and predicted, while larger scale impacts over the whole system are difficult to measure or assess. In attempting to predict impacts, it's important to determine the extent and size of the cone of depression that will result from well pumping. This information can be determined in part by measuring certain characteristics of the aquifer. These characteristics are "transmissivity" and "storativity."

The transmissivity of an aquifer is the ease with which water can move through it, while storativity describes the amount of water that can be stored and removed by pumping. Once transmissivity and storativity have been determined, the extent and magnitude of a cone of depression can be predicted for various pumping rates and durations of pump-

**Table 6-1. Summary of groundwater availability data, Sheridan County Groundwater Area**

| Aquifer | Average annual withdrawal (af) (1983-1988) | Maximum annual withdrawal (af) (1988) | Annual volume permitted by DNRC (af)[g] | Estimated sustainable yield (af) | Volume available (af) |
|---|---|---|---|---|---|
| Westby-Dagmar outwash, Coalridge channels, and recharge channels | 4,821 af[a] | 6,025 af[a] | 8,126.45 af[b,g] | 6,330 af[a]<br>to<br>16,000 af[c] | 16,000 (high est.)<br>-4,821 (avg. actual use)<br>11,179 af MAX |
| Missouri River terrace gravels (preglacial Missouri River) | d | d | 299 af[b,g] | 2,000 af[e] | 1,701 af[e] |
| Tributary outwash | d | d | 0 af[b,g] | 2,000 af[e] | 2,000 af[e] |
| Big Muddy alluvium | d | d | 625 af[b,g] | 2,300 af[f] | 1,675 af |

[a] From MBMG (Donovan 1988)
[b] DNRC
[c] Sheridan County Water Reservation Application (Gallagher 1986)
[d] Reliable estimates are not available
[e] These channels are about the same size as Big Muddy Creek.
[f] DNRC 1990
[g] Total of large irrigation projects

ing. Figure 6-13 illustrates how a cone of depression forms when a well is pumped in an unconfined (or water table) aquifer, and in a confined aquifer. The potentiometric surface is the level to which water will rise in a well completed in a confined aquifer due to the water under the confining layer being pressurized. Drawdown is the difference between the static water level (or potentiometric surface) and the pumping water level (or potentiometric surface for pumping).

Transmissivity calculated for outwash aquifers based on aquifer test data in Sheridan and Roosevelt counties are highly variable, ranging from 1,920 gpd/ft to 1,100,000 gpd/ft (Donovan 1988). Despite this large range in estimates, most are between 100,000 gpd/ft and 500,000 gpd/ft. The average transmissivity value from 10 wells completed in the Westby-Dagmar aquifer is 385,000 gpd/ft.

Table 6-2 shows expected drawdowns at various distances from a pumping well associated with withdrawal of 1,100 gpm for 100 days at an average transmissivity of 385,000 gpd/ft. Applying these conditions with an assumed storativity of 0.10, which would reflect unconfined or water table conditions, indicates the cone of depression would extend about 10,700 feet from the pumping well. Drawdown would

**Figure 6-13. Cone of depression formed when a well is pumped, showing drawdown at observation wells**

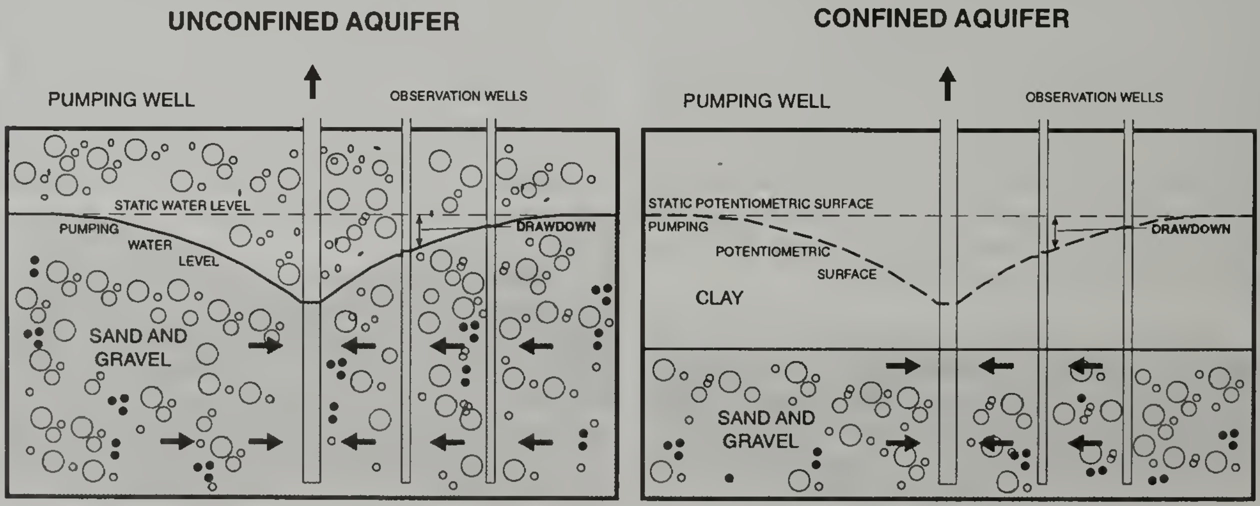

UNCONFINED AQUIFER
CONFINED AQUIFER

**Table 6-2. Expected drawdowns at various distances from a pumping well**

| | |
|---|---|
| Pumping rate | 1,100 gpm |
| Duration | 100 days |
| Volume pumped | 486 af |
| Transmissivity | 385,000 gpd/ft |

**Storativity = 0.10 (unconfined, water table aquifer)**

| | | | | | |
|---|---|---|---|---|---|
| Distance from well in feet | 1,000 | 5,000 | 10,000 | 40,000 | 100,000 |
| Drawdown in feet | 1.5 | .5 | .1 | 0 | 0 |

**Storativity = 0.0003 (confined aquifer)**

| | | | | | |
|---|---|---|---|---|---|
| Distance from well in feet | 1,000 | 5,000 | 10,000 | 40,000 | 100,000 |
| Drawdown in feet | 3.4 | 2.4 | 1.9 | 1.0 | 0.8 |

be less than 1 foot below static water level at a distance of about 2,300 feet from the well. If storativity is only 0.0003, which would reflect a confined aquifer, drawdown could extend tens of miles and be more than 1 foot up to 40,000 feet (7.8 miles) from the pumping well (see Figure 6-13).

The numbers shown in Table 6-2 are provided to show the range of drawdowns one might expect from a project using 1,100 gpm continuously for 100 days. This generates a total withdrawal of some 486 af. A variety of site-specific factors could affect actual drawdowns. Foremost are actual transmissivity and storativity values at the site. Other factors include the amount of water that may return to the aquifer during the period of withdrawal (return flow) and the presence of recharge sources such as surface water bodies that would limit the cone of depression. Aquifer boundaries and overlapping cones of depressions from multiple wells could cause greater drawdowns in certain areas.

Overall, drawdown of a typical project-size well is much greater where the aquifer is confined than where it is unconfined. However, drawdowns in unconfined portions of the aquifer are more likely than the larger drawdowns associated with confined portions of the aquifer to cause direct impacts on shallow water table features such as ponds, springs, rivers, or lakes. This is because the confining layer separates the aquifer from surface water. The confined aquifer impacts tend to be on other users that also use the aquifer—things like flowing wells stopping, lowering pump intakes, and higher pumping costs. Impacts felt over an entire aquifer system result from the system adjusting to conditions caused by pumping withdrawal and its associated cone of depression. The amount of water withdrawn and consumed ultimately results in some combination of: (1) a reduction of water stored in the aquifer, (2) an induced increase in recharge to the aquifer, and (3) a decrease in discharge from the aquifer.

A long-term, net reduction of water stored in the aquifer would be manifested in water levels declining year after year until a new equilibrium is reached. Induced recharge may include the capture of more precipitation or surface water in the natural recharge area of the aquifer. In the case of the outwash channels, it could cause an increased influx of water from surrounding bedrock aquifers, which typically contain poorer quality water. A decrease in discharge would result in diminishment of natural spring discharge and seepage to lakes, streams, or other aquifers at the discharge end of the aquifer.

Such impacts may be manifested in a large area over a long period of time and require detailed monitoring to determine their magnitude. It is unlikely that such impacts can be precisely attributed to a particular well. Instead, these larger scale impacts should be viewed as resulting from all withdrawals in the entire system.

As explained in Chapter Four, water levels declined 6 to 9 inches a year in portions of the Westby channel from 1982 to 1990, and lake levels in Medicine Lake and other lakes managed by USFWS have been below management levels in most years during the same period. Although drought may account for most of these declines, groundwater withdrawals also contributed to them.

Donovan (1988) states that as much as 100,000 af of the approximately 114,000 af of water stored in lakes in the Medicine Lake drainage might be connected to the Westby-Dagmar aquifer. These connected lakes, which include Medicine Lake, are susceptible to decline as a result of groundwater withdrawals for irrigation. The importance of maintaining shallow groundwater in order to sustain connected surface water bodies is the most obvious constraint to groundwater irrigation development in the Westby-Dagmar channel.

The groundwater flow model developed by Donovan (1988) provides some insight as to how pumping could affect water levels at Medicine Lake. Using this model, Gallagher (1991) suggests that pumping for an additional 51 projects over a 90-day season in the Westby-Dagmar aquifer would cause 3.6 inches of drawdown at Medicine Lake, with higher drawdowns possible at smaller lakes. Gallagher did not specify the location of these hypothetical systems and did not predict what impacts might occur beyond the end of the 90-day irrigation. The estimated drawdown of 3.6 inches for 51 projects suggests that the drawdown associated with the proposed 13 to 15 projects sought by the conservation district (Gallagher 1991) would be about one inch at Medicine Lake at the end of the 90-day irrigation season.

The drawdown associated with withdrawals of groundwater for irrigation would occur throughout the discharge area of the aquifer. Donovan's (1988) analysis indicates natural evapotranspiration would be lost through the loss of wetland vegetation at the fringes of the discharge area, and the annual water discharge from the lakes managed by USFWS would decrease.

Groundwater withdrawals probably would reduce flow in Big Muddy Creek. Donovan's analysis suggests that if 4,500 af are withdrawn annually from the Westby-Dagmar channel, outflow from Medicine Lake will be reduced by 3,790 af annually. Future withdrawals would be expected to decrease surface water outflow from the Medicine Lake drainage to a similar degree each year. Also, withdrawals of groundwater from Big Muddy Creek channel outwash might reduce groundwater and surface water discharge downstream. The impact of an individual well on Big Muddy Creek drainage would depend on factors such as the degree to which the aquifer tapped by the well is connected to the stream, amount of return flow to the aquifer, and the distance and depth of the groundwater diversion in relation to Big Muddy Creek.

In summary, new wells may cause local impacts in the well vicinity and more widespread impacts may be associated with the cumulative effect of many wells. The cause of more widespread impacts are difficult to determine. For the purposes of managing the aquifer system, it would make sense to determine beforehand what conditions of quantity and quality are optimum, acceptable or unacceptable, and then base future development on information indicating how the aquifer is faring in regard to such conditions.

**Impacts of the Grant All Alternative:** The Sheridan County Conservation District has applied to reserve 133,587 af/yr from the Westby-Dagmar aquifer and adjoining outwash channels.

The volume of water applied for greatly exceeds the volume of water estimated to be available from the aquifers. According to the Sheridan County Conservation District application, the intent is to stop development when the aquifer's sustainable yield is reached (Appendix 1). Water would be allocated for two or three projects each year with no more than eight to ten projects completed in the first five years. Aquifer response and recovery would be monitored carefully to determine if new irrigation were adversely affecting the aquifer. The district would seek technical assistance.

The impacts of this alternative hinge largely on what the Sheridan County Conservation District determines to be the sustainable yield from the aquifers. The case-by-case groundwater permitting system proposed by the conservation district may not adequately address cumulative, indirect impacts at long distances from wells. For example, if a well is a mile from a protected wetland and data suggest the well could cause a 1-inch decline of water levels at the wetland, a permit could be issued on the basis of minimal impact. If the same reasoning is used for each of a dozen more wells, the cumulative impacts could reduce water levels at the wetland on the order of a foot.

The Westby-Dagmar aquifer might be able to yield 50,000 af/yr to wells (based on the estimated recharge volume from Donovan (1988)) without necessarily affecting any senior water rights for other wells. However, pumping to this extent would drastically alter the hydrology of the aquifer; basically, it would reduce water elevation in the aquifer and capture water that otherwise would be discharged. Lakes and wetlands connected to the aquifer would decrease in size and eventually be eliminated. Water may have to be pumped from greater depths at greater cost.

Thus, the "sustainable yield" criterion may not satisfy uses of the aquifer that require higher groundwater levels, such as lakes and wetlands connected to the aquifer system.

Nevertheless, this alternative may be an improvement on the existing permitting system. DNRC issues permits on a case-by-case basis, and does not limit the number of wells that can be permitted in 1 year or any period of time. The Sheridan County Conservation District, however, would allocate water for a limited number of projects each year. The conservation district would manage groundwater in the area and plan for future development.

**Impacts of the Partial Granting Alternative:** The limited amount of water that would be granted under this alternative probably would not cause major impacts to the hydrology of the Westby-Dagmar aquifer system. The 1,509 af/yr that would be granted for the Westby-Dagmar channel was determined by subtracting the estimated average annual withdrawal from Donovan's (1988) estimate of total available groundwater that could be used for irrigation. Although groundwater pumping permitted by DNRC already exceeds Donovan's estimated sustainable yield, the volumes of water permitted are based on unlikely scenarios of continuous pumping of all wells throughout the irrigation season, as explained in Chapter Four.

Estimates of the amounts of water that could be granted for the Missouri River terrace gravels, the tributary outwash, and the Big Muddy alluvium are not reliable, and it is unknown whether these aquifers will support such withdrawals. The incremental approach to development and monitoring of groundwater conditions by the conservation district would provide more information to refine these estimates.

The Partial Granting Alternative, because of its limited volume, might not effectively "tie up" all available groundwater in the basin, thereby allowing additional water to be developed through water use permits. Therefore, the Sheridan County Conservation District may not be able to control all water development, which may, in turn, limit its ability to manage the system.

**Impacts of the Coordinated Groundwater Development Alternative:** If the controlled groundwater area proposed in this alternative is established, the Coordinated Groundwater Development Alternative would provide a means of creating a management team that could work toward optimal use of the aquifer system. Groundwater levels and trends could be established in various areas to determine whether permits should be issued or pumping curtailed. This alternative could allow more pumping and development during periods of water surplus and curtailment of pumping during droughts.

This alternative provides an opportunity for parties other than the conservation district to have a hand in deciding the fate of the aquifer system, yet places the decisions in the hands of the people who live and work in the area. This approach would minimize groundwater declines and associated impacts while allowing for reasonable development.

**Groundwater projects outside the Sheridan County Groundwater Area:** Water reservation applications for groundwater outside of the Sheridan County Groundwater Area include 11 applications for municipal use and four applications for irrigation use. Table 6-3 summarizes some information concerning these applications.

Nine of the applications are for groundwater from either alluvium or other shallow aquifers that may be hydrologically connected to alluvium of major streams. Four of the applications are for groundwater from deep bedrock (sandstone) aquifers. One application is for groundwater from the Flaxville Gravel and one application is for groundwater from a small alluvial or outwash aquifer along an intermittent stream tributary to the East Fork Poplar River.

Proposed municipal projects at Poplar, Scobey, and Wolf Point would use wells that would be placed close to streams and capture streamflow by induced infiltration. Some water pumped by the well would be derived from groundwater stored in the aquifer, especially right after pumping begins. The cone of depression would rapidly intercept the nearby stream, and water in the stream would infiltrate through the streambed and the aquifer to supply water to the well. The amount of water supplied by the stream rather than by stored groundwater increases with time until nearly all water pumped is actually being supplied by the stream. The most significant impact of these projects would be depletion of streamflow at about the same magnitude as the pumping rate of the well.

Municipal projects at Chinook, Harlem, Havre, Malta, and Plentywood, and irrigation projects DA-31 and DA-281 include proposed wells that would tap alluvial aquifers at locations that generally are

**Table 6-3. Summary of applications for groundwater outside of the Sheridan County Groundwater Area**

| Project | Volume (af/yr) | Maximum rate (gpm) | Aquifer |
|---|---|---|---|
| Chinook | 200 | 350 | Glacial outwash or alluvium in tributary drainages south of the Milk River |
| Circle | 78 | 275 | Hell Creek Sandstone and Fox Hills Sandstone |
| Ekalaka | 20 | 50 | Fox Hills Sandstone |
| Harlem | 200 | 350 | Alluvium or ancestral Missouri River gravels |
| Havre | 475 | 1050 | Milk River alluvium |
| Malta | 137 | 300 | Milk River alluvium |
| Plentywood | 235 | 500 | Big Muddy Creek alluvium |
| Poplar | 448 | 1000 | Poplar River alluvium |
| Scobey | 168 | 500 | Poplar River alluvium |
| Wibaux | 70 | 200 | Fox Hills Sandstone and alluvium |
| Wolf Point | 504 | 1000 | Missouri River alluvium |
| DA-71 | 502 | 1571 | Flaxville gravel |
| DA-31 | 208 | 628 | West Fork Poplar River |
| DA-281 | 235 | 898 | Alluvium |
| CT-294 | 50 | 180 | Hell Creek Sandstone and Fox Hills Sandstone |

far enough from streams by depth, horizontal distance, or geologic strata to greatly reduce the likelihood of induced infiltration. Pump tests at any proposed well could determine whether the well induces infiltration from a nearby stream.

The amount of water withdrawn from these proposed wells ultimately would result in some combination of (1) a reduction of water stored in the aquifer, (2) an induced increase in recharge to the aquifer, and (3) a decrease in discharge from the aquifer. It is likely that the proposed wells would affect flows in adjacent rivers. Such reductions in flow could occur partially at times other than during the period of pumping and would not be measurable.

Municipal projects at Circle and Wibaux and irrigation project CT-294 include proposed wells that would tap regionally extensive, deep bedrock aquifers. Impacts would include water level declines in the vicinity of the well in the aquifer tapped and a decrease in discharge from the aquifer. Such decreases in discharge would occur over such a large area that the impacts would be negligible.

Irrigation project DA-71 would derive water from the Flaxville Gravel. This project would likely decrease flow in springs along Spring Creek.

## LEGAL WATER AVAILABILITY

Water will be legally available for reservations only after all senior water rights are satisfied. If water users are concerned that reservations may adversely affect them, they can object to the reservations and be heard during the contested case hearing process ARM 36.12.103(1)(i). This process will consist of a formal contested case hearing (sworn testimony with lawyers and cross examination), and less formal public hearings.

Soon after this draft EIS is distributed, water right holders in the lower Missouri River basin will be notified by mail of the proposed reservations, and objection procedures will be outlined in the notice. This notice also will be published in newspapers of general circulation throughout the basin. It will cost $50.00 to file objections to reservations and participate in the formal contested case hearing (ARM 36.12.103(1)(i). Water users who do not want to pay the $50.00 but still want to voice their comments or concerns can present their testimony at no cost during public hearings that will be held by the Board in communities throughout the basin. Notice of these hearings also will appear in local newspapers. The Board will use findings from testimony presented at both the formal contested case hearing and public hearings when reaching its decision on the reservation applications.

Like all water rights, water reservations are enforceable and reservants will be responsible for enforcing their rights. In the Management Plan section of its water reservations application, DFWP has outlined procedures it would take to enforce its reservation with respect to junior water users. DFWP's management plan is included in Appendix I. The other applicants have not indicated how they might enforce their reservations.

## STATE WATER RIGHTS - CLAIMS AND PERMITS

Reservations cannot preclude senior water right holders—those with a priority date earlier than July 1, 1985, in the lower Missouri River and Milk River subbasins and Sheridan County Groundwater Area, and July 1, 1989, in the Little Missouri River subbasin—from using water to the extent of their existing rights.

For this EIS, DNRC searched its water rights data base to identify streams and aquifers where reservations are proposed, and where water right holders filed objections to applications for water use permits between July 1973 and June 1993. Table 6-4 identifies some areas where questions may arise regarding the legal availability of water for reservations. It does not mean that water availability will not be questioned for any other water sources, or that water cannot be reserved from the streams and aquifers identified in the table. Many questions regarding the legal availability of water for reservations will be resolved during the contested case hearing.

Permits issued after the priority dates for reservations would be junior to reservations. However, the Board may subordinate the reservations to junior permits that were issued before the Board reaches its decision on the reservation applications if it finds that they would not unreasonably interfere with the purpose of the reservation (see Chapter Two for a discussion of subordination). In Appendix A, permits with priority dates junior to reservations are summarized by subbasin.

If the Board grants reservations, the reserved water will not be available for new appropriation by permit because it will be committed either for consumptive use or instream flows. Amounts of water that would still be available for appropriation if all instream reservations are granted to the maximum amount allowed by law are summarized in Appendix J. Granting reservations for consumptive use also would reduce the amount of water available for new appropriation (see Water Quantity and Distribution section). However, DNRC, with approval of the Board, may issue a temporary permit to use water reserved for consumptive use until the reservant needs the water.

Reservations would give reservants legal standing to object to applications for new permits and to changes in senior and junior water rights. Reservants also would have the right to participate in the adjudication process where final decrees have not been issued.

Action on the reservation applications will proceed even though the statewide adjudication is not complete. The adjudication process will take many years, and by law, the Board has to act on water reservations by December 31, 1994. Reservations will not be adjudicated.

### MILK RIVER SUBBASIN

A closure on the Milk River in Montana for its entire length upstream from the Vandalia diversion dam during certain times of the year has restricted the issuance of new water use permits, but the closure stipulations do not mention water reservations. Only one of the proposed reservations appears to be in definite conflict with the specifics of the basin closure—that part of the Hill County Water and Sewer District's reservation request that seeks to divert water from the outlet works of Fresno Reservoir. Requests for Milk River water below Fresno Reservoir by Havre, Chinook, and Harlem would divert river water only during times of the year when the river is not closed to permits. Each of these communities and Malta also have requested year-round reservations for groundwater from wells that would be near the river. Reservation requests for proposed water storage projects by the Liberty and Blaine county conservation districts as included in the Consumptive Use Alternative would store water on Milk River tributaries, which are not closed. Irrigation projects proposed by the Valley County Conservation District on the Milk River are downstream from the Vandalia diversion dam. The Board will have to decide if and

**Table 6-4. Streams where reservations are applied for and where water rights holders objected to permit applications (including objections to wells) between July 1973 and June 1993**

| Subbasin-Drainage | Source | Number of permit applications objected to | Type of reservations requested at source | | |
|---|---|---|---|---|---|
| | | | Irrigation | Municipal | Instream |
| **Lower Missouri** | | | | | |
| Missouri River | Missouri River | 47 | X | | X |
| | Wells | 9 | | X | |
| Redwater River | Redwater River | 4 | | | X |
| Poplar River | Poplar River | 9 | X | | X |
| | Middle Fork Poplar R. | 1 | X | | X |
| | West Fork Poplar R. | 2 | X | | X |
| | Spring Creek | 1 | X | | |
| | Coal Creek | 2 | X | | |
| | Wells | 10 | X | X | |
| **Milk** | | | | | |
| Milk River | Milk River | 40 | X | X | |
| | Battle Creek | 6 | X | | X |
| | Beaver Ck.(Hill County) | 5 | | | X |
| | Clear Creek | 1 | | | X |
| | Frenchman River | 4 | | | X |
| | Link Coulee | 1 | | X | |
| | Lost Coulee | 1 | | X | |
| | Peoples Creek | 4 | | | X |
| | Rock Creek | 9 | | | X |
| | Beaver Ck.(Phillips County) | 9 | | | X |
| | Wells | 67 | X | X | |
| **Little Missouri** | | | | | |
| Little Missouri | Little Missouri River | 2 | X | | X |
| | North Butte Creek | 4 | X | | |
| | Cottonwood Creek | 1 | X | | |
| Boxelder Creek | Boxelder Creek | 4 | X | | X |
| | Fresh Water Draw | 1 | X | | |
| Little Beaver | Little Beaver Creek | 4 | X | | X |
| | HS Creek | 1 | X | | |
| Beaver Creek | Beaver Creek | 12 | X | | X |
| | Rattlesnake Creek | 1 | X | | |
| | Wells | 2 | X | | |
| **Sheridan County Groundwater Area** | | | | | |
| (Big Muddy | Wells | 39 | X | X | |
| Creek basin) | Whitetail Creek | 1 | X | | |

how the Milk River closure may apply to water reservations.

## INTERNATIONAL WATERS

On most international streams in the lower Missouri River basin, the Canadians have yet to develop the full share of water allocated to them by international treaty and agreements. Water shortages in the Milk River subbasin are especially acute, and if Canada develops its full share of Milk River water, even less water will be available for reservations requested in that basin. The hydrologic analysis for the Blaine County Conservation District's proposed Battle Creek Reservoir that is included in the Consumptive Use Alternative does not take into account the real possibility of more water development by Canada. The Canadians have proposed a reservoir of approximately 3,200 af on Battle Creek in Canada, and construction on this reservoir might begin this spring. More water development also could be implemented by the Canadians in the Poplar River drainage, which would leave less water available for both instream and consumptive use in that drainage. Reservations would not affect the upstream Canadian water rights.

### FORT PECK RESERVOIR

Because its rights to store and regulate water at Fort Peck Dam are senior to any water reservations, the Corps of Engineers would not be required to modify its operation of the dam to meet either instream or consumptive use reservations.

## FEDERAL RESERVED RIGHTS

### INDIAN TRIBES

Tribal reserved rights for the Fort Peck Indian Reservation are large and senior to any state water reservations. This means the Fort Peck tribes would be entitled to use water ahead of any of the reservants. Senior instream rights for the Fort Peck tribes on the Poplar River would preclude the use of state-reserved water for consumptive use in that basin during much of the year. They would not affect the DFWP instream reservation request on the Poplar River upstream from the reservation boundary.

Federal reserved rights for the Fort Belknap, Rocky Boy's, and Blackfeet reservations in the Milk River subbasin are all senior to any other water reservations. When the extent of these rights is determined and the tribes develop their water, it is likely that less water will be available for the water reservations.

The tribes of the Turtle Mountain Reservation in North Dakota own scattered parcels of land in the lower Missouri River basin. Among these holdings are 40 acres in Roosevelt County Conservation District's project CBI-15; all of Sheridan County Conservation District projects 32.3, 64.2, and 64.3; and 72 acres of project 64.1, also in the Sheridan County. If it is determined that the tribes have federal reserved rights for these parcels, granting the conservation district's water reservations for them could duplicate irrigation water rights for this land.

### FEDERAL AGENCIES

For the most part, reserved rights held by federal agencies would not conflict with the reservations requested under this process. The National Park Service's consumptive use rights for Milk River tributaries in Glacier Park are very small and, because these streams are high in the watershed, instream rights for them would not affect or be affected by state reservations requested downstream. Similarly, streams in the Custer National Forest that may have federal reserved rights are all upstream from reservations requested in the Little Missouri River subbasin. One proposed storage project that would use reserved water is located on a tributary to Black Coulee, but is downstream from the Black Coulee National Wildlife Refuge.

Federal reserved rights for the Lake Bowdoin National Wildlife Refuge probably reflect the usual operations of that system, which primarily divert springtime Milk River flows into the reservoir. Because these rights are senior to any new state reservations, they could preclude upstream reservants on the Milk River and its tributaries from diverting water when flows are low.

### HILL COUNTY WATER AND SEWER DISTRICT

The Hill County Water and Sewer District has requested a reservation for Marias River water. Other reservations for water in the upper portions of the Missouri River basin were already decided on by the Board in June 1992. The water and sewer district contends that it was not notified of the water reservation proceeding in the upper basin and therefore did not have the opportunity to apply to reserve Marias River water at that time. The Board will have to decide whether to make an exception and consider the district's request for upper basin water. Unless the Board decides otherwise, the district's reservations, if granted, would have a July 1, 1985, priority date, just like all upper basin reservations. The priority of this reservation with respect to other reservations granted in the upper portions of the basin also would have to be decided by the Board.

# WATER STORAGE

## IMPACTS

Five water storage projects are included in the reservation applications as summarized in Table 6-5. All are in the Milk River subbasin, and the largest by far is the 18,593 acre-feet Battle Creek reservoir project. The irrigation storage projects are only included in the Consumptive Use Alternative. The City of Chinook proposal to store water for municipal use in Threemile Coulee would be included in the Consumptive Use, Combination, and Instream alternatives.

If water reservations are granted, less water would be legally available to store in the future. At the public scoping meetings, there was concern that storage was not adequately addressed in the water

**Table 6-5. Proposed storage projects included in the Consumptive Use Alternative**

| Storage Project | Stream | capacity (af) | Purpose |
|---|---|---|---|
| BL-131 | Tributary of Black Coulee | 164 | irrigation |
| BL-171 | Link Coulee/Battle Creek | 172 | irrigation |
| BL-181 | Battle Creek | 18,593 | irrigation |
| Chinook LI-241 | Threemile Coulee/Milk River | 1,000 | municipal |
| LI-241 | Lost Coulee | 310 | irrigation |
|  | Total | 19,929 |  |

reservation process and that reservations for instream flows would preclude storage projects in the future. Others thought that storage could serve as an alternative to instream reservations for supplying instream flows.

A case-by-case analysis would be necessary to determine how reservations would affect a specific storage project, or if storing water is feasible on a stream.

To provide an example, DNRC analyzed a hypothetical reservoir on Boxelder Creek in the Little Missouri River subbasin near Mill Iron. The dam would be a 93-foot high earth-fill structure with a storage volume of 108,562 af and annual reliable yield of 27,422 af/yr. Total construction costs would be about $25,000,000, and annualized costs considering interest, operation, and maintenance were estimated at $1,682,576. The cost of water supplied by the reservoir would be approximately $61.00/af. The hypothetical reservoir was designed to provide releases adequate to match DFWP's 4 cfs minimum instream flow request on Boxelder Creek from December through March and 7 cfs the remainder of the year. If the reservoir were to be operated to also supply DFWP's requested channel maintenance flows, the reliable yield would drop from 27,422 af/yr to 12,188 af/yr and costs of the water would rise to $138.00/af.

Given the relatively low value of instream water in the lower Missouri River basin (see Chapter Seven), it would not pay to build a reservoir like this to provide water solely for instream flows. More likely, a reservoir would be constructed as a multi-purpose facility. In the case of this hypothetical reservoir, water could be used for downstream irrigation (an analysis determined there is enough irrigable land downstream to use the stored water) and recreational use. It was assumed that a minimum pool of 20 percent of the total reservoir capacity would be maintained for reservoir fisheries and recreation.

Such a project would be expensive to build, and the $61/af cost of the water is relatively high. For comparison, the proposed Battle Creek Dam project, which is included only in the Consumptive Use Alternative, would provide supplemental water at $39.00/af to existing irrigation systems. Further analysis would be needed to determine the value of other benefits such as reservoir recreation and flood control. Potential adverse effects, such as those to migratory fish populations, also would need to be taken into account.

The Board can act only on water storage projects that have been applied for in this proceeding. If the Board is concerned that reservations would preclude future storage projects, it could modify or condition reservations appropriately. Water reservations would not affect the operation of existing storage facilities.

## WATER QUALITY

### GENERAL IMPACTS

The proposed municipal reservations are very small relative to available streamflow and groundwater supplies. As a result, their effect on water quality is minor.

Reservations for irrigation projects have the greatest potential to adversely affect water quality and increase municipal water treatment cost by:

1. Reducing the volume of water available to transport and dilute chemical constituents in surface water and groundwater;
2. Increasing concentrations of salts, trace-elements, nutrients, and pesticides in shallow groundwater, irrigation return flows, and surface water;
3. Modifying water temperature through alteration of the seasonal pattern of streamflow by storage and diversion projects; dewatering of streams in late summer may lead to increased water temperatures and resulting reductions in dissolved oxygen.

Existing water quality information retrieved from EPA's STORET database was inadequate to develop a water quality model allowing quantitative description of potential effects of reservations on water quality. Water quality records are sporadic at most locations, measurement stations are sparsely distributed, and information for many possible contaminants is not routinely collected. Consequently, development of a water quality model that would allow systematic comparison of water reservation alternatives was not possible. An alternative approach, screening level analysis, was used instead.

The Consumptive Use Alternative was analyzed and the expected increase in late summer (usually July and August) TDS concentrations estimated. This was done by examining existing water quality data for key locations (usually water availability model nodes) and estimating typical concentration values for dry years (80th percentile). The effect of the Consumptive Use Alternative on this dry year, dry month, baseline concentration value was then estimated using flow depletion information provided by the water availability model. Where sufficient information was available, seasonal effects on water quality were estimated.

The estimates of change in dissolved solids concentration are based on the assumption that a reduction in flow volume is accompanied by a proportional increase in concentration. For example, a 10 percent reduction in monthly streamflow volume results in a 10 percent increase in estimated baseline TDS concentration.

The relative effects of other alternatives on water quality were evaluated relative to existing conditions in the Consumptive Use Alternative. As shown in Figures 6-1 through 6-12, there may be little difference in the effect that the Consumptive, Combination, Instream, and No Action alternatives have on the seasonal distribution and volume of streamflow. In these situations, the range of effects on water quality should be similarly small.

The effect of the alternatives on nutrients, pesticides, and some other water quality parameters, such as trace-element concentrations, water temperature, and dissolved oxygen, was not estimated because adequate baseline information was not available. However, two useful generalizations can be made. First, within any alternative, the more land irrigated, the greater the reduction in streamflow and potential increase in parameter concentration. Second, if existing contaminant levels exceed water quality criteria, then additional water consumption will likely increase the frequency and magnitude of the problem.

**Arsenic:** Arsenic originating in geothermal areas of Yellowstone Park persists in reduced concentrations in the lower Missouri River main stem (Figure 4-9). While arsenic concentrations are much lower than in the upper basin, they are high enough to cause concern. If new irrigation with water containing arsenic causes local and downstream surface water increases in arsenic concentration, then the state's ambient water quality standard will be violated.

The upper Missouri River basin draft EIS for proposed water reservations (DNRC 1992) states that use of Missouri River water for irrigation could increase arsenic concentrations in return flows and ultimately the Missouri River (p. 183). However, recent research by DNRC and BUREC indicates that many upper basin soils store arsenic, and return flows may have lower arsenic concentrations than applied water. DNRC and Montana State University recently initiated a 3-year study of the fate of arsenic in irrigated soil and groundwater of the upper Missouri River basin. This study is examining the long-term arsenic adsorption capacity of various soils, how tightly arsenic is bound to soils, whether or not this binding process is permanent, and how irrigation management affects the fate of arsenic. Results of this investigation will help to determine whether proposed irrigation projects will violate the ambient arsenic standard.

### MILK RIVER SUBBASIN

**Battle Creek:** The proposed Battle Creek Reservoir (project BL-181) and projects LI-241 and BL-171, included in only the Consumptive Use Alternative, would have the greatest effect on water quality in median flow years when water is available for use. In dry years, little water is available for use and the effect of consumptive depletions on water quality would be small.

The principal effect of the Battle Creek storage project would be to reduce existing seasonal variability in total dissolved solids (TDS) loads and concentrations below the dam. Reduced runoff during March and April might slightly increase TDS concentrations as the volume of flow available to dilute salty base flows is reduced. However, substantially increased flow in Battle Creek during May-September is likely to substantially reduce TDS concentrations during these months.

Under existing conditions, TDS concentrations in Battle Creek near its mouth during spring runoff vary from about 200 to 800 ppm, with an average of 400 ppm. Summer and fall concentrations vary from about 460 ppm to 1,200 ppm, with an average of about 750 ppm. Flow regulation by project BL-181 would tend to reduce the seasonal variation in TDS and create new average conditions between 400 ppm and 750 ppm. Besides improving water supply for irrigation, flow regulation may improve overall irrigation water quality.

Major ions and parameters such as Sodium Adsorption Ratio (SAR) tend to rise and fall along with flows, much the same as TDS, but no estimate of the magnitude of these changes was possible. Effects of the Battle Creek project on trace-elements, nutrients, total suspended solids, dissolved oxygen, water temperature, and pH could not be estimated with existing information.

Some useful water quality information was generated for a study of a proposed storage project on Battle Creek in Canada, which provides insights on changes that might occur in Montana due to project BL-181. Saskatchewan Water Corporation and the Prairie Farm Rehabilitation Administration have proposed a storage project on Battle Creek several miles north of the border (UMA Engineering 1990). The Canadian project is smaller (3,200 af active storage) than project BL-181 (18,600 af active storage). Because the Canadian project is smaller, water in it would have a shorter residence time.

UMA Engineering (1990) estimated that in spite of the short residence time, the Canadian project would be subject to high phosphorous and nitrogen loadings and would develop algae growth similar to many southern Saskatchewan lakes and reservoirs. Summer blooms of blue-green algae may occur. Water discharge from the reservoir could be nutrient enriched, which might encourage growth of aquatic weeds in downstream channels and reservoirs. High summer production of aquatic plants and subsequent decomposition could cause oxygen depletion in winter. Oxygen depletion would cause major changes in other water quality parameters. Trace elements could be solubilized, ammonia could develop toxic concentrations, and hydrogen sulfide might be generated. The combination of high primary productivity, warm temperatures, and shallow water would place the reservoir at risk for summer kill of aquatic life (UMA Engineering 1990). Further study would be necessary to determine if these types of effects would occur in the proposed Battle Creek Reservoir project BL-181.

**Milk River:** Water quality impacts in the Milk River drainage were evaluated for two scenarios under the Consumptive Use Alternative. The first scenario assumes that all water reservations in the upper and lower Missouri basins are developed and that the Virgelle Diversion is not constructed; the second scenario assumes all water reservations are developed and the Virgelle Diversion is constructed. Potential effects on water quality in the Milk River are evaluated for three locations—at Havre, near Harlem, and at Nashua.

### WATER RESERVATIONS WITHOUT VIRGELLE DIVERSION

**Milk River at Havre:** Changes in water quality in this scenario would be small.

**Milk River near Harlem:** The largest reduction in flow would occur in March or April and the largest increase in August and September. Reduction of flow during spring runoff and increased flow during the late summer and early fall might have a slight beneficial effect on water quality by reducing sediment loads at high flow and increasing dilution at low flow.

**Milk River at Nashua:** Reduction in spring flow and increased flow during the late summer might improve water quality by reducing sediment concentrations and increasing dilution at low flow. In general, the largest flow reductions, due primarily to increased storage in reservoirs, would occur in the spring when TDS is lowest (typically in the range 400 to 600 ppm); the greatest increases in flow would come in August-October when TDS concentrations sometimes exceed 1,000 ppm. Increasing flow by several percent during low flow periods probably would produce a proportional reduction in TDS concentrations.

### WATER RESERVATIONS WITH THE VIRGELLE DIVERSION

**Milk River at Havre:** The Virgelle Diversion would divert water from the Missouri River into the Milk River basin above Havre. The Missouri River typically is cooler, less saline, and has lower turbidity and suspended-sediment concentrations than the Milk River. The transfer of Missouri River water into the Milk River basin generally would reduce TDS and other concentrations of major ions in the Milk River. However, water temperature may be different at different times in the two rivers. It is not known whether changes in the thermal regime of the Milk River could violate standards for aquatic life. These effects, if they occur, would be greatest in the upper Milk River basin and diminish downstream. Effects of reservations proposed in the Milk River above Havre would be minuscule.

**Milk River at Nashua:** Dissolved arsenic concentrations in the Missouri River near Virgelle typically range from 3 ppb to 20 ppb with an average of about 14 ppb. Dissolved arsenic concentrations in the Milk River at Nashua range from 1 ppb to 8 ppb with an average of about 3 ppb. Therefore, the Virgelle Diversion would increase arsenic concentrations in the Milk River. For a further discussion of the effects of the Virgelle Diversion project, see DNRC's EIS for the upper Missouri River basin water reservation application (DNRC 1991).

Effects on water quality due to proposed reservations in the Milk River subbasin under all alternatives would be small.

### LOWER MISSOURI RIVER SUBBASIN

**Lower Missouri River:** Some of the parcels proposed for irrigation under the Consumptive Use Alternative contain soil units that are saline and would require special management (e.g. soil moisture base, irrigation scheduling) to prevent or minimize increases in salt content of return flows.

Dissolved-solids concentration in outflow from Fort Peck Dam varies from about 350 ppm to 550 ppm on a seasonal basis, and is poorly correlated with daily fluctuations in outflow volume, which is not surprising since Fort Peck Reservoir serves as a large "mixing-bowl" and smoothes out variation. Assuming a 4 percent reduction in annual flow volume under the Consumptive Use Alternative, the baseline range in dissolved-solids concentration would increase proportionally by about 4 percent. This amount of increase would be difficult to measure and the effect on downstream water quality difficult to detect.

The observed range in dissolved-solids concentration in the Missouri River near Wolf Point is from 360 ppm to 450 ppm. This range was found in data collected between 1967 and 1973 and is probably less representative of baseline conditions than the longer record (1975-1985) available at Fort Peck. Assuming the Fort Peck data represent present conditions and that dilution capacity would be reduced 12 percent under the Consumptive Use Alternative during dry years, the maximum dissolved-solids would rise from the present 550 ppm to about 620 ppm.

Observed TDS concentrations in the Missouri River near Culbertson range from 244 ppm to 580 ppm (1967-1982). Observations of specific conductance in September 1987 indicate maximum TDS concentrations of about 650 ppm. The public drinking water standard is 500 ppm. Increases of 8 to 18 percent, which may occur during the late summer under the Consumptive Use Alternative, would increase TDS concentrations to about 700 ppm to 770 ppm. Concentrations this high would occur infrequently, but would reduce the potability of domestic water supply and might increase municipal treatment costs.

Concentrations of trace-elements in the lower Missouri River are elevated above typical background values, and reductions in dilution capacity might cause further increases. Water quality records for the Missouri River near Culbertson show that total cadmium, lead, manganese, nickel, and iron concentrations occasionally exceed public drinking water standards. However, the number of trace-element observations is small (about 15 to 30 samples over the period 1970-1992), and the frequency and duration of exceedance is not known.

The Combination Alternative would provide for less irrigation than the Consumptive Use Alternative and would have less effect on water quality. This alternative would have 45 percent less irrigated acreage, with about 45 percent less water used. Many of the parcels included under the Consumptive Use Alternative but eliminated under the Combination Alternative contain problem soils (poor drainage, erosive soils, saline soils), which, if irrigated, could contribute to the salt and sediment load of the Missouri River.

Water quality in outflows from Fort Peck Reservoir and in the Missouri River near Wolf Point under the Combination Alternative would be similar to that resulting from implementation of the Consumptive Use Alternative. Water quality of the Missouri River between Culbertson and the North Dakota state line would be less affected by depletions under the Combination Alternative.

The Instream Alternative would provide for about 90 percent less irrigation than that proposed in the Consumptive Use Alternative and would affect the dilution and assimilation capacity of the lower Missouri River in dry years much less than the Consumptive Use or Combination alternatives.

**Poplar River:** Irrigation proposed under the Consumptive Use Alternative would occur along the West Fork, Middle Fork, and East Fork of the Poplar River. Existing streamflow is intermittent and water quality is generally poor in these streams (Figure 4-11). Suitability of water for irrigation is often marginal due to high TDS and boron concentrations and high SAR values. Further depletions of streamflow would increase concentration of pollutants, and new irrigation development would require careful application of water and special management to minimize decline in soil productivity and crop yields. Reduction in summer streamflow would increase the frequency of no flow, high water temperature, and low dissolved oxygen conditions that harm aquatic life. Other alternatives would have no noticeable effect on streamflow, and it is assumed that water quality effects would be similarly small.

In normal years, the Poplar River contributes about 1.3 percent of the average annual streamflow and chemical load of the Missouri River near Culbertson (less in dry years). Because of this, the effects of consumptive use of Poplar River water on the main stem Missouri River are small under all alternatives.

**Big Muddy Creek:** Groundwater development in the Big Muddy Creek basin would have a small effect on water quality in the Missouri River.

### LITTLE MISSOURI RIVER SUBBASIN

**Little Missouri River:** The C-3 water quality classification of surface water in the Little Missouri River drainage reflects the generally poor quality of water. Only spring snowmelt runoff is suitable for irrigation. The lowest recorded TDS concentrations, just east of the Montana border near Camp Crook, South Dakota, occur during spring snowmelt in March, April, May, and June. Depending upon the magnitude of runoff, TDS may vary from about 250 ppm to 900 ppm in these months with SARs of 2 to 5. However, during the remainder of the year, TDS values are typically in the range of 900 ppm to 3000 ppm with SAR values of 4 to 8, and this water is marginal to unsuitable for irrigation use.

Under the Consumptive Use Alternative, flow depletions would be only about 1 percent of average annual flow in typical years, and changes in water quality would be similarly small. In July and August of dry years, flow depletions would be greater than 50 percent. Flow depletion in dry years would increase TDS and SAR, and irrigation development would require careful application of water and special management to minimize decline in soil productivity and crop yields. Reduction in summer streamflow would increase the frequency of no flow, high water temperature, and low dissolved oxygen conditions that harm aquatic life.

Irrigation under the Combination Alternative would be about 30 percent less than under the Consumptive Use Alternative and would have similar effects on water quality. The Instream Alternative would have slightly less effect than the Combination Alternative.

**Boxelder Creek:** Variation in TDS and SAR on Boxelder Creek are similar to those of the Little Missouri River at Camp Crook, South Dakota, although SAR may be consistently higher. Streamflow follows the typical pattern of prairie streams fed by snowmelt runoff. In March through June, flows are relatively large and the runoff, although frequently muddy, has the smallest concentrations of chemicals, lowest temperatures, and highest dissolved oxygen. As flows diminish in July and August, groundwater becomes the source of most surface flow and the concentrations of most chemical constituents increase.

Under the Consumptive Use Alternative, flow depletion in dry years would increase TDS and SAR, and irrigation development would require careful application of water and special management to minimize decline in soil productivity and crop yields. Reduction in summer streamflow would increase the frequency of no flow, high water temperature, and low dissolved oxygen conditions that harm aquatic life.

The Combination Alternative would include less irrigation and would have slightly less effect on water quality. The Instream Alternative would have less effect than either the Consumptive Use or Combination alternatives.

**Little Beaver Creek:** Water quality in Little Beaver Creek follows the same seasonal pattern as the other Little Missouri River tributaries with an observed TDS range of about 600 to 2800 ppm. Specific conductance measurements during spring runoff indicate that TDS concentration drops as low as 200 ppm. SAR ranges from 2.5 to 9 with the larger values occurring at baseflow. Sulphate, boron, and sodium concentrations are typically large during baseflow, which occurs in August through February of typical years. Late summer and fall flows near the

North Dakota state line typically are less than 0.5 cfs. In dry years, runoff occurs in March through June, flows taper rapidly in July, and flow is intermittent from August through February.

Under the Consumptive Use Alternative, flow depletions in dry years would increase TDS and SAR, and irrigation development would require careful application of water and special management to minimize decline in soil productivity and crop yields. Reduction in summer streamflow would increase the frequency of periods with no flow, high water temperature, and low dissolved oxygen, all of which harm aquatic life.

The Combination Alternative reduces the amount of proposed irrigation by about 30 percent and would have slightly less effect on water quality. The Instream Alternative would have less effect than either the Consumptive Use or Combination alternative.

**Beaver Creek:** Water quality in Beaver Creek is similar to that in Little Beaver Creek. Monthly observations at two locations—Wibaux and near Trotters, North Dakota—show a similar range and seasonal pattern of variation in TDS and SAR between Beaver and Little Beaver creeks.

Under the Consumptive Use Alternative, flow depletion in dry years would increase TDS and SAR, and irrigation development would require careful application of water and special management to minimize decline in soil productivity and crop yields. Reduction in summer streamflow would increase the frequency of periods with no flow, high water temperature, and low dissolved oxygen conditions, all of which harm aquatic life.

The Combination Alternative would irrigate 80 percent less land and would have a much smaller effect on water quality than the Consumptive Use Alternative. The Instream Alternative would have less effect than either the Consumptive Use or Combination alternatives.

### SHERIDAN COUNTY GROUNDWATER AREA

Sufficient information is not available to make reliable site-specific estimates of the effects of groundwater development on the quality of water in streams, lakes, and aquifers of the Big Muddy Creek basin. However, it is highly likely that the cumulative effect of extensive groundwater development on water quality would be significant, and that existing water quality problems such as high TDS, SAR, and nitrate would increase in magnitude and frequency.

The water quality classification (C-3) of surface water in the Big Muddy Creek basin indicates that water in aquifers, lakes, and streams is generally of poor quality. In the Big Muddy Creek basin, salinity frequently limits the beneficial uses of water.

There are probably some situations where additional pumping of groundwater could induce increased poor quality surface water recharge of groundwater and thereby degrade groundwater quality. There could be other situations where the reverse is true—pumping would induce recharge of good quality surface water. Evaluation of such impacts would require additional site-specific information.

The effects of proposed groundwater development on surface-water quality in the Big Muddy Creek basin depends upon the following factors:

1. The amount and quality of water withdrawn, the type of soil irrigated, and the amount of water consumed;
2. The specific location and regional distribution of groundwater withdrawals; and
3. The effectiveness of future groundwater monitoring and management efforts.

Water quality within the Westby-Dagmar aquifer and adjoining outwash channels is variable, and some wells developed there produce relatively high quality water with few constraints on use, while others produce poor quality water that is unsuitable for irrigation and other uses (Donovan 1988). Depending upon the quality of groundwater used, impacts to local surface water systems could be small or large. The use of water with high salt content could lead to saline soil drainage and salinized irrigation return flows that increase salinity of shallow groundwater, lakes, and streams.

The spatial distribution of wells in a given area also exerts a strong influence on water quality. A given number of wells in a small area would magnify drawdown effects. The water balance and water quality of shallow lakes that occupy the ancestral Missouri River channel are sensitive to fluctuations in adjacent groundwater levels. Fluctuations on the order of 1 foot can reverse the direction of flow of surface water and groundwater. A few inches in groundwater elevation can control the size and existence of wetlands.

The potential for adverse effects on water quality is greatest under the Grant All Alternative, lower under the Partial Development Alternative, and least under the Coordinated Development Alternative.

## SOILS

The degree to which soils are affected by irrigation depends upon existing land use, soil type, and irrigation management practices. For instance, irrigating dry cropland has much different effects on soils than irrigating native rangeland. Irrigation in this semi-arid region can increase soil salinity, which has a profound effect on long-term soil productivity.

The concentration of salts in soil increases as salt from irrigation water is removed by evaporation or used by plants. This increase can be controlled by leaching, which is the practice of applying more irrigation water than crops require. Leaching prevents excessive salinity in the root zone by moving salts downward through the soil faster than they are added by irrigation water. Without leaching, soil salt levels in a semi-arid climate will increase and productivity will decrease.

Several changes occur when dryland farming is replaced by irrigation. Wind erosion rates decrease during the irrigation season on cultivated fields because wet soils are more resistant to erosion. Irrigation enhances crop cover during the growing season and provides more protection from wind and water erosion than dryland crops. Irrigation also increases plant residues returned to the soil. Soil structure is improved, microbe populations benefit from the added food source, and nitrogen fertility is enhanced.

The effects of converting rangeland and riparian land to irrigation are quite different from those associated with converting cropland. Researchers have measured decreases in organic carbon of 25 to 60 percent as a result of cultivating rangeland, with total nitrogen decreases of 24 to 50 percent (Blank and Fosberg 1989; Baur and Black 1981; Campbell and Souster 1982; Dormaar 1979). Organic matter losses of 15 percent were measured by Lehane and Staple (1943) within the first 10 months after cultivation. Annual losses would be greatest after the first 20 years and would stabilize after the first 50 years (Doughty et al. 1954). These changes are likely to reduce the ability of soils to hold water, increase soil susceptibility to erosion, and increase the need for chemical fertilizers (Blank and Fosberg 1989; Campbell and Souster 1982).

The effects could be reduced somewhat by alfalfa production. Alfalfa, as a nitrogen fixing plant, increases the amount of nitrogen available to subsequent crops. The addition of alfalfa residues would lessen the loss of organic carbon. The perennial cover of an alfalfa crop would reduce erosion throughout the year and provide additional moisture by trapping snow. An alfalfa-grain rotation would disrupt weed and insect pest cycles established under dryland cropping patterns.

Unless otherwise noted, supplemental irrigation of currently irrigated land would not have substantial effects on soils.

Municipal requests generally would have minor adverse effects on soils. Soil erosion and compaction would occur at well sites, storage tank construction sites, and along pipeline routes. Short-term losses in soil productivity would occur until revegetation stabilizes disturbed areas.

### SOIL IMPACTS DUE TO PIPELINE AND CANAL CONSTRUCTION

Pipeline and canal construction can reduce agricultural production by compacting soil and mixing soil layers. Mixing topsoil with subsoil reduces organic matter and nutrients available to plants, increases stoniness, and leaves higher concentrations of salts near the surface (Mutrie and Wishart 1987). Compaction crushes the structure of the topsoil and reduces porosity, creating an impenetrable layer or "hardpan."

These adverse effects can be minimized with proper procedures. To eliminate mixing, soil can be double-lifted during trenching. With this technique, the topsoil is excavated, stored, and replaced separate from the subsoil. During construction, either the entire right-of-way could be cleared or just one side, including the trench and soil storage area. If the working site is not cleared, deep ripping may still be necessary to correct compaction caused by heavy vehicle traffic. Retaining stubble and plants would also help prevent compaction.

Although not specifically stated in the applications, it is assumed that irrigation pipelines would be buried at least 3 feet deep to clear tillage equipment and protect them from vandalism. Soil disturbances would be greatest for pipelines with a diameter greater than 17 inches. Table 6-6 shows miles of large diameter pipeline that would be needed for proposed irrigation projects along the Missouri River.

No large diameter pipelines would be used for projects in other subbasins.

Erosion of streambanks and steep slopes also would occur during and after pipeline construction. Soil erosion could be reduced with proper drainage, timely construction, and reclamation measures. These techniques are commonly used during pipeline construction. Proper drainage could be ensured by installing cross-ditch and berm structures and subdrains. Construction should be scheduled when streamflow is low and when the soil is dry to avoid rutting and compaction. Recontouring streambanks and slopes to their original configuration and planting native plants or cover crop species would decrease erosion. In highly erodible soil, mulch could be used to protect the soil until vegetation grows.

Soil productivity would be lost on land converted to canals, and soils would be disturbed along rights-of-way during canal construction. Access roads to and along canal routes also would compact soils. Miles of canals required for irrigation projects are summarized in Table 6-6.

**Table 6-6. Soil disturbances that would occur due to pipeline and canal construction for each alternative[a]**

| | Alternative | | | | | |
|---|---|---|---|---|---|---|
| | Consumptive Use | | Instream | | Combination | |
| Project | pipelines (feet) | canals (feet) | pipelines (feet) | canals (feet) | pipelines (feet) | canals (feet) |
| VA-02 | 16,748 | | | | | |
| VA-03 | 13,775 | | | | 13,775 | |
| MC-5A | 1,763 | | | | 1,763 | |
| MC-08 | 13,390 | | | | 13,390 | |
| MC-11 | 9,471 | | | | 9,471 | |
| MC-12 | 6,155 | | | | 6,155 | |
| MC-99 | 6,670 | | | | 6,670 | |
| RI-01 | 11,542 | | | | 11,542 | |
| RI-03 | 5,848 | | 5,848 | | 5,848 | |
| RI-05 | 2,526 | | | | 2,526 | |
| RI-06 | 2,197 | | | | 2,197 | |
| RI-07 | 11,794 | | | | | |
| RI-09 | 10,583 | | | | 10,583 | |
| RI-10 | 4,550 | | 4,550 | | 4,550 | |
| RI-11 | 2,520 | | 2,520 | | 2,520 | |
| RI-12 | 1,643 | | 1,643 | | 1,643 | |
| RI-13 | 1,389 | | | | 1,389 | |
| RI-14 | 3,181 | | | | 3,181 | |
| RI-15 | 19,620 | | | | 19,620 | |
| CBI-1 | 3,942 | | 3,942 | | 3,942 | |
| CBI-2 | 5,899 | 15,077 | 5,899 | 15,077 | | |
| CBI-3 | 1,257 | 18,818 | 1,257 | 18,818 | | |
| CBI-4 | 859 | 14,121 | | | | |
| CBI-5 | 1,059 | | 1,059 | | | |
| CBI-7 | 5,448 | 12,662 | | | | |
| CBI-10 | 5,433 | | 5,433 | | | |
| CBI-11 | 19,419 | | 19,419 | | | |
| CBI-12 | 6,524 | 36,264 | | | | |
| CBI-13 | 24,899 | 116,285 | | | | |
| CBI-15 | 7,979 | | 7,979 | | | |
| CBI-16 | 7,727 | | 7,727 | | | |
| CBI-17 | 5,509 | | 5,509 | | 5,509 | |
| CBI-18 | 4,629 | 17,129 | | | | |
| CBI-19 | 285 | 7,156 | 285 | 7,156 | 285 | 7,156 |
| CBI-21 | 1,434 | | 1,434 | | | |
| TOTALS | 247,667 | 237,512 | 74,504 | 41,051 | 126,559 | 7,156 |

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[a] Specific information about pipeline and canal size can be found in individual applications.

## IMPACTS OF THE CONSUMPTIVE USE, INSTREAM, AND COMBINATION ALTERNATIVES

### LOWER MISSOURI RIVER SUBBASIN

Projects that pump water from the lower Missouri River would irrigate land on the floodplain and adjacent terraces and benches. Where projects would clear riparian vegetation, especially in the Consumptive Use and Combination alternatives, organic matter would be lost and soil fertility would decrease. Erosion might occur on some units of irrigation projects VA-02, CBI-13, and CBI-18, which are located on steep land just outside the river valley and are included in the Consumptive Use Alternative. However, most of this land is now dryland grain fields. With proper irrigation water management, the perennial cover of the proposed alfalfa crop would reduce water erosion. Erosion would temporarily occur along a pipeline for irrigation project VA-02, included in only the Consumptive Use Alternative, where the pipeline goes up a slope as steep as 20 percent. Projects in the lower Missouri River subbasin that would irrigate fine sandy loam and sandy loam soils prone to wind erosion are listed in Table 6-7. An alfalfa cover would reduce wind erosion in the portions of these projects that are now farmed for grain. Where native vegetation would be removed, wind erosion would increase, at least in the short term until an alfalfa coverage is established.

Projects that would irrigate saline soil are listed in Table 6-7. The saline soils in these projects are mostly small areas surrounded by better soil. Without adequate leaching, soluble salts can increase over time and damage productivity. Drainage may be poor on some of the land, and artificial drainage such as subsurface tile or drainage ditches may be required. Project CBI-13 in the Consumptive Use Alternative would irrigate glacially derived soils that are slightly salty. Artificial drainage, which has been included in the design plans for this project, would be necessary to prevent localized concentrations of salty water.

Slow infiltration of irrigation water also might be a problem for the projects which contain areas of clayey soils. Sprinkler application rates would have to be carefully controlled or artificial drainage might be necessary to keep water from ponding on the surface of these soils. Project CBI-20, included in the Consumptive Use Alternative, includes wetland soils where the water table is high and drainage is poor. Irrigation water would pond on the surface on much of this project, which is included in only the Consumptive Use Alternative.

In the Poplar River drainage, project DA-171, which is included in the Combination and Consumptive Use alternatives, is in an area with saline seep problems. There is a small pond of water in the proposed project, but it is not known if the pond water is saline. With proper management, the deep roots of an alfalfa crop could capture water that might otherwise percolate beyond the root zone. This would reduce the potential for saline seeps at this project site. If water applications are excessive and lead to deep percolation of water, saline seepage could become a problem.

Projects DA-71 and DA-221, which are included in the Combination and Consumptive Use alternatives, contain land that has been planted with grass as part of the Conservation Reserve Program. The sandy loam soils at these project are susceptible to blowing. If the projects are converted to irrigated alfalfa, wind erosion would be a problem until the alfalfa crop becomes established. The potential for wind erosion is also high for Daniels County Conservation District projects listed in Table 6-7, which are in the Poplar River drainage.

### MILK RIVER SUBBASIN

Soil productivity would be permanently lost on land flooded by reservoirs, including approximately 1,532 acres for the Battle Creek Reservoir project BL-181, 50 acres for project BL-131, 17 acres for project BL-171, and 55 acres for project LI-241. Soil adjacent to the reservoirs could also be lost to shoreline erosion. Soil would be disturbed when fill material is excavated for the dams, and construction activity would disturb and compact soils near the dam site. Road construction would cause additional soil productivity losses. Such impacts would be greatest for the Battle Creek Reservoir (project BL-181). These reservoir projects are included only in the Consumptive Use Alternative.

Severe erosion problems have resulted from uncontrolled irrigation return flows entering the Milk River in the vicinity of project VA-211. If the erosion is not controlled, a portion of the project land could be lost.

Wetland soil is located in portions of projects VA-211 and VA-261. Irrigation water applied to these soils would pond on the surface because drainage is poor and the water table is high.

**Table 6-7. Soil concerns for proposed irrigation projects in the lower Missouri River subbasin**

| Subbasin | Soils prone to wind erosion | Saline soils | Clayey soils | Alternatives |
|---|---|---|---|---|
| CBI-1 | X | X |  | CU,I,C |
| CBI-2 | X |  |  | CU,C |
| CBI-3 | X | X |  | CU,C |
| CBI-4 | X | X |  | CU |
| CBI-6 | X |  |  | CU,C |
| CBI-7 | X |  | X | CU |
| CBI-9 | X |  |  | CU |
| CBI-10 | X |  |  | CU,C |
| CBI-11 | X | X |  | CU,C |
| CBI-12 | X |  |  | CU |
| CBI-13 | X | X |  | CU |
| CBI-14 |  | X |  | CU,I,C |
| CBI-15 | X | X |  | CU,C |
| CBI-17 | X |  |  | CU,I,C |
| CBI-18 | X | X |  | CU |
| CBI-19 | X | X |  | CU,I,C |
| CBI-20 |  |  | X | CU |
| CBI-21 | X | X |  | CU,C |
| DA-251 | X |  |  | CU,C |
| DA-252 | X |  |  | CU,C |
| DA-261 | X |  |  | CU |
| DA-341 | X |  |  | CU,C |
| DA-371 | X |  |  | CU,I,C |
| MC-01 |  |  | X | CU,I,C |
| MC-03 |  |  | X | CU,I,C |
| MC-O5 |  |  | X | CU,C |
| MC-05A |  |  | x | CU,C |
| MC-06 |  | X |  | CU,I,C |
| MC-08 | X | X |  | CU,C |
| MC-09 | X |  | X | CU,I,C |
| MC-9A | X |  | X | CU |
| MC-10 | X |  |  | CU,C |
| MC-11 | X |  |  | CU,C |
| MC-12 | X | X |  | CU,C |
| MC-99 | X | X |  | CU,C |
| RI-01 |  |  | X | CU,C |
| RI-02 | X |  | X | CU,I,C |
| RI-03 | X |  |  | CU,I,C |
| RI-05 | X |  | X | CU,C |
| RI-07 | X |  | X | C |
| RI-09 |  |  | X | CU,C |
| RI-10 | X |  |  | CU,I,C |
| RI-12 | X |  |  | CU,I,C |
| RI-13 |  |  | X | CU,C |
| RI-15 | X |  |  | CU,C |
| VA-02 | X |  |  | CU |

CU = Consumptive Use Alternative
I = Instream Alternative
C = Combination Alternative

### Little Missouri River Subbasin

Plowing native prairie would disturb soil with high wind erosion potential on projects indicated in Table 6-8. Wind erosion could occur on these projects until a crop cover is established. The cover provided by an alfalfa crop, once established, would protect susceptible soils from wind erosion on projects CT-121, CT-122, CT-294, LB-171, WI-75, and WI-192, all of which are now dryland farmed for grain and included in the Consumptive Use Alternative.

Water erosion could occur on water-spreading projects if care is not taken during project construction and operation. Soil highly susceptible to water erosion is present on water-spreading projects indicated in Table 6-8. Soil on most other water-spreading projects is at least moderately susceptible to water erosion. Severe water erosion has already occurred due to a small dam in the vicinity of proposed projects CT-153 and CT-154 (Photo 6-1).

Land leveling and constructing ditches and dikes for water-spreading projects could mix soil layers. Care should be taken during project construction to ensure that topsoil remains at the surface of fields between ditches and spreader dikes.

Project CT-294, included in the Consumptive Use Alternative, would sprinkler irrigate saline soils, and leaching would be required to prevent further salt accumulations. Saline soil also is present on water-spreading projects indicated in Table 6-8. On these projects, infiltration could be slow, and water may pond behind spreader dikes. The excessive moisture could destroy crops immediately adjacent to the dikes, allowing undesirable plants such as foxtail barley to invade. Clayey soils could cause similar problems on projects CT-293 and CT-330. The water table is already too high for crops on portions of project WI-151 in the Consumptive Use Alternative, which contains wetland soil.

**Table 6-8.Soil concerns for proposed irrigation projects in the Little Missouri River subbasin**

| Project | Soils prone to wind erosion | Soils prone to water erosion | Saline soils | Clayey soils | Alternatives |
|---|---|---|---|---|---|
| CT-102 | | X | X | | CU |
| CT-071 | X | | | | CU,I,C |
| CT-141 | | | X | | CU,C |
| CT-151 | X | X | X | | CU,C |
| CT-152 | | X | | | CU,C |
| CT-154 | | X | | | CU,C |
| CT-162 | | | X | | CU,C |
| CT-171 | | | X | | CU,C |
| CT-243 | | X | | | CU,C |
| CT-244 | | X | | | CU,C |
| CT-261 | | X | | | CU,C |
| CT-262 | | X | | | CU,C |
| CT-291 | | X | | | CU,C |
| CT-293 | | | | X | CU,C |
| CT-310 | | X | | | CU,C |
| CT-330 | | | | X | CU,I,C |
| LB-141 | X | | | | CU,C |
| LB-161 | X | | | | CU |
| LB-172 | X | | | | CU,C |
| LB-181 | | | X | | CU,C |
| LB-182 | | | X | | CU,C |
| WI-72 | X | | | | CU |
| WI-93 | | | X | | CU,C |
| WI-161 | | | X | | CU |
| WI-192 | | X | | | CU |
| WI-233 | X | | X | | CU,C |
| WI-234 | X | | | | CU,C |

CU = Consumptive Use Alternative
I= Instream Alternative
C= Combination Alternative

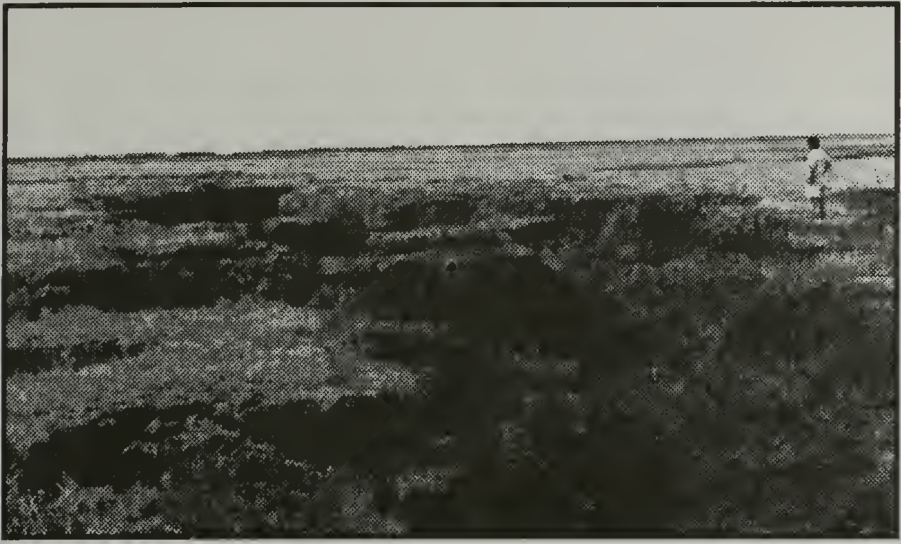

**Photo 6-1. Severe erosion in the vicinity of projects CT-153 and CT-154**

Water-spreading projects would use spring runoff water that is generally high in suspended sediments and low in salts. In some instances, water spreading may improve soil quality by depositing suspended sediments on fields.

#### Sheridan County Groundwater Area

On approximately one-third of the land where irrigation projects are proposed in Sheridan County, soil is sandy, sandy loam, or fine sandy loam, all of which are susceptible to blowing. Plowing rangeland or land enrolled in the Conservation Reserve Program would expose these soils to wind erosion, at least for the short term until alfalfa becomes established. For projects where land presently farmed in a grain-fallow rotation system is converted to irrigation, crop cover and soil moisture would increase and soil blowing would decrease.

Inclusions of clayey, salty, and alkaline soils are located in many of the proposed irrigation projects. These soils are not suitable for irrigation due to inadequate drainage and permeability and compaction problems. Overall, these soils make up approximately 6 percent of the total project area, and less than 25 percent of any one project.

Soils on most land in Sheridan County where irrigation projects are proposed are loams and clay loams derived from glacial till. The soils are generally well drained at the surface, but the subsoils below are often more poorly drained and can contain relatively impermeable calcareous clay layers. In the long-term, irrigating with water that is high in salts may further restrict infiltration through these subsoils and lead to waterlogging and salt accumulation near the surface.

## STREAM CHANNEL FORM

### General Impacts and Considerations

DFWP has requested channel maintenance flows and minimum instream flows for many streams in the lower Missouri River basin. The legal protection of these streamflows by reservation may help to maintain the channel characteristics of these streams.

#### Lower Missouri River Subbasin

Some land proposed for irrigation under projects listed in Table 6-9 is very near Missouri River streambanks that are actively eroding. One field in project RI-11A has already partially eroded away. Many of these projects also would require the clearing of streamside trees, which would accelerate bank erosion rates. Such impacts could be reduced by moving the projects away from the river bank and retaining a belt of trees on streambanks. The belt of trees would not stop erosion but would slow it.

Projects with pump sites along actively eroding riverbanks are listed in Table 6-10. In other instances, such as for projects CBI-4, CBI-6, CBI-9, and CBI-10, sediment is being deposited at the pump sites. Many farmers in the area have adapted to unstable streambanks by using portable, floating pumps (Photo 6-2). More permanent pumping stations would be required for larger proposed projects, such as CBI-13 (Photo 6-3).

Where larger pumping stations are constructed, bank stabilization with riprap may be required. Also, because developing land for irrigation would involve large investment, some farmers may attempt to stabilize eroding stream banks adjacent to irrigated fields. Bank stabilization can lead to problems. Often when a streambank is stabilized, the force of water and subsequent bank erosion is redirected somewhere downstream. Where the Missouri River's banks are stabilized, natural stream migration will be restricted.

**Table 6-9. Proposed projects on the lower Missouri River where irrigated land would be immediately adjacent to eroding river banks**

| Project | Consumptive Use | Combination | Instream |
|---|---|---|---|
| CBI-8 | X | X | |
| CBI-14 | X | X | X |
| CBI-15 | X | X | |
| CBI-21 | X | X | |
| RI-01 | X | X | |
| RI-03 | X | X | X |
| RI-05 | X | X | |
| RI-10 | X | X | X |
| RI-11A | X | X | |
| RI-12 | X | X | X |
| RI-13 | X | X | |
| RI-14 | X | X | |
| RI-15 | X | X | |
| MC-05A | X | X | |
| MC-6A | X | X | |
| MC-08 | X | X | |
| MC-11 | X | X | |
| MC-99 | X | X | |
| VA-02 | X | | |
| VA-03 | X | | |

**Photo 6-2. A portable irrigation pump on the lower Missouri River**

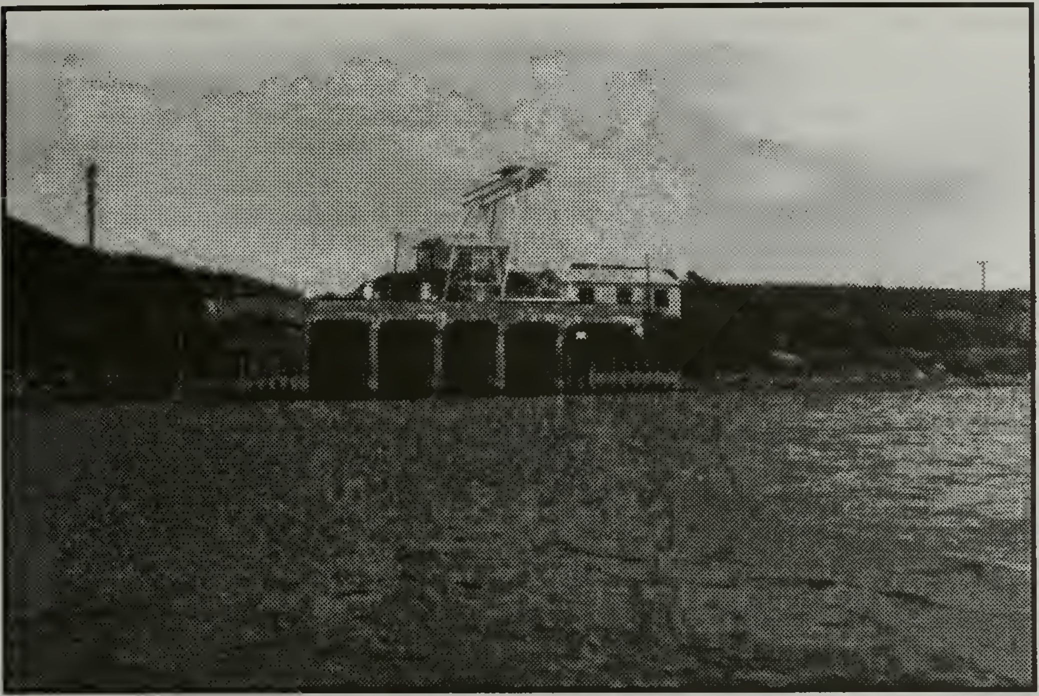

**Photo 6-3. A permanent pumping station for a large irrigation project on the lower Missouri River**

**Table 6-10. Proposed projects along the lower Missouri River where pump sites would be located on eroding streambanks**

| Project | Consumptive Use | Alternative Combination | Instream |
|---|---|---|---|
| CBI-1 | X | X | X |
| CBI-2 | X | X | |
| CBI-3 | X | X | |
| CBI-8 | X | X | |
| CBI-12 | X | | X |
| CBI-14 | X | X | X |
| RI-01 | X | X | |
| RI-03 | X | X | X |
| RI-05 | X | X | |
| RI-07 | X | | |
| RI-09 | X | X | |
| RI-13 | X | X | |
| RI-14 | X | X | |
| MC-04 | X | X | |
| MC-05A | X | X | |
| MC-6A | X | X | |
| MC-08 | X | X | |
| MC-09 | X | X | X |
| MC-10 | X | X | |
| MC-11 | X | X | |
| VA-02 | X | | |

The streamflow reductions that would occur in the lower Missouri River as a result of project development under any of the alternatives would have little effect on the form of the stream channel. This is because these streamflow reductions are relatively small in comparison to annual flows and seasonal and daily streamflow fluctuations.

On the Poplar, East Poplar, and West Poplar rivers, consumptive use of water for which reservations are requested would substantially reduce streamflows during the growing season, water levels would drop, and times of no flow would become more frequent. This would expose streambeds more often and allow vegetation to become established in them, the first step toward narrowing of the stream channel. Narrower stream channels have less capacity to transport water and are therefore more likely to cause flooding. Such impacts would be greatest under the Consumptive Use Alternative, less under the Combination Alternative, and minimal under the Instream Alternative.

### MILK RIVER SUBBASIN

The Battle Creek Dam that is included in the Consumptive Use Alternative would markedly reduce peak streamflows in Battle Creek below the dam, and most of the upper stream's sediment supply would be trapped in the reservoir. These two conditions would create an apparent paradox. Without the peak streamflows and their erosive power, the stream channel may narrow below the dam as vegetation takes root in previously unstable portions of the streambed. Spring runoff streamflows could be mimicked by requiring periodic high releases from the reservoir, but clear water released from the reservoir (the sediment would be trapped in the reservoir) would erode the streambed. As a result, the stream channel could both deepen and narrow for some distance downstream and any periodic high releases from the reservoir would only amplify this problem. All these factors should be studied carefully before approval of any final operating plans or mitigating measures for the dam.

Project BL-131 in the Consumptive Use Alternative would dam a small tributary to Black Coulee. Some of the flow into this tributary is from springs. Flows would be reduced below the dam, which could result in vegetation encroaching into this small stream channel. The other proposed dams included in the Consumptive Use Alternative probably would have minor effects on creek channels that usually are dry under existing conditions.

Projects that divert flows during the irrigation season in the lower Milk River would reduce already low water levels in this stream channel, and periods of no flow would increase. These factors could contribute to vegetation becoming established in the streambed and subsequent channel narrowing. These projects are included in the Consumptive Use and Combination alternatives.

Projects VA-211 and VA-521 in the Consumptive Use and Combination alternatives would pump water up 20- to 30-foot banks that are actively eroding along the Milk River. The proposed pump locations for these projects could be moved to a point where the streambanks are more stable.

A water reservation was granted to BUREC as part of the upper Missouri River basin water reservation proceeding. This reservation allows water from the Missouri River to be diverted to the Milk River as part of the Virgelle Diversion project. This would raise Milk River streamflows during the irrigation season, and thereby increase bed and bank erosion in the river, especially near the point where the diversion would enter the stream.

### LITTLE MISSOURI RIVER SUBBASIN

The effects of water-spreading irrigation projects on the channels of major streams in this subbasin would be minor because peak flow reductions in these streams would be small. However, the water-spreading projects could cause substantial reductions to peak flows in many small tributary streams, and their channels might narrow in response.

Care would have to be exercised in designing, constructing, and operating water-spreading projects. If the water diverted for spreading is not properly controlled, severe erosion might occur, and the entire course of small streams could be altered. SCS guidelines could be used in the design and installation of all projects to avoid such impacts.

Pump projects on Box Elder Creek and the Little Missouri River would increase the frequency of very low and zero summertime streamflows in these streams. When flows become low or cease, portions of these stream channels are left dry, and vegetation could become established in the dry streambed. During times of high flow, this vegetation would trap sediment, which could lead to an eventual reduction in stream channel size. These impacts would be greatest under the Consumptive Use Alternative, slightly less under the Combination Alternative, and small under the Instream Alternative.

## VEGETATION

Developing irrigation projects would affect native plant communities. Fields would be cleared and plowed and pipelines, canals and diversion structures would be built. Flooding by reservoirs would destroy terrestrial plant communities. Projects that would irrigate dryland farming areas would not alter native plant communities.

**Upland Prairie:** Dry upland prairie sites would be plowed in all subbasins and under all reservation alternatives. Plowing would be greatest under the Consumptive Use Alternative, less under the Combination Alternative, and much less under the Instream Alternative (Table 6-11).

In the Sheridan County Groundwater Area, a maximum of 2,465 acres of dry prairie could be plowed under the Grant All and Partial Granting alternatives. As much as 1,280 acres could be converted under the Coordinated Groundwater Development Alternative.

**Moist Prairie:** Effects to moist prairie vegetation outside of the Missouri River floodplain would be greatest under the Consumptive Use Alternative, much less under the Combination Alternative, and negligible under the Instream Alternative (Table 6-12). Most of the moist prairie acreage lost in the Milk River subbasin under the Consumptive Use Alternative would be inundated by Battle Creek Reservoir under project BL-181. The other reservoir projects in the Consumptive Use Alternative also would affect moist prairie sites. Project BL-131 would submerge a brushy riparian area.

In the Sheridan County Groundwater Area, impacts to moist prairie vegetation could occur directly as land is plowed, or indirectly if pumping for irrigation projects lowers water tables. Impacts would be greatest in the Grant All Alternative, where 715 acres of moist prairie would be plowed. In the Partial Granting Alternative, it is unlikely that as much moist prairie would be disturbed, although all 715 acres would be eligible for development. A maximum of 282 acres of moist prairie could be converted to farmland under the Coordinated Groundwater Development Alternative. The amount of moist prairie that could be affected if groundwater pumping for irrigation projects lowers water tables is unknown. However, these impacts would be greatest by far under the Grant All Alternative and much less under the Partial Granting and Coordinated Groundwater Development Alternatives.

**Woody Draws and Bottomlands Outside the Missouri River Valley:** Impacts would affect wooded areas in uplands and along Missouri River tributaries, especially under the Consumptive Use and Combination alternatives (Table 6-13). For this impact analysis, wooded land is defined as including floodplain forests, mixed prairie (prairie with scattered trees or groves of trees), shrubland, and woody draws. Excluding the Missouri River bottomlands, only 5 acres of this vegetation type, all in the Little Missouri River subbasin, would be lost under the Instream Alternative.

In Sheridan County, a maximum of 20 acres of wooded land could be converted to cropland under the Grant All and Coordinated Groundwater Development alternatives. No wooded land would be cleared under the Partial Granting Alternative.

Some woody draw vegetation would be destroyed as a result of project construction, either through clearing for fields or construction of diversion and conveyance structures. Dewatering of springs and seeps also would affect woody draw habitat. Projects CBI-16, LB-11, LB-151, WI-43, and WI-92 in the Consumptive Use and Combination alternatives and project CBI-13 in the Consumptive Use Alternative would destroy some woody draw vegetation. Sheridan County Conservation District projects 40.4, 84.2, and 85.8 also would remove woody draw vegetation.

**Bottomlands Adjacent to the Lower Missouri River:** Table 6-14 summarizes vegetation changes that would occur in bottomlands adjacent to the Missouri River as a result of irrigation project development. These impacts are further summarized in Table 6-15 to make them comparable to the results of earlier vegetation studies conducted along the Missouri River by Hoar and Erwin (1985) (see Table 4-7). Appendix F contains vegetation maps of the Missouri River valley bottomlands for existing conditions and the Consumptive Use Alternative. Impacts to plant communities along the lower Missouri River would be especially acute under the Consumptive Use and Combination alternatives and much less under the Instream Alternative. Some large continous blocks of cottonwood forest along the lower Missouri River would be fragmented or destroyed under the Consumptive Use and Combination Alternatives.

**Table 6-11. Acres of upland prairie that might be plowed due to reservations in the lower Missouri, Milk, and Little Missouri River subbasins**

| Subbasin | Consumptive Use | Alternative<br>Instream | Combination |
|---|---|---|---|
| Lower Missouri River | 1,155 | 97 | 822 |
| Milk River | 749 | 0 | 11 |
| Little Missouri River | 2,539 | 422 | 1,701 |

**Table 6-12. Acres of moist prairie that might be plowed due to reservations in the lower Missouri, Milk, and Little Missouri River subbasins**

| Subbasin | Consumptive Use | Alternative<br>Instream | Combination |
|---|---|---|---|
| Lower Missouri River[a] | 63 | 0 | 17 |
| Milk River | 1,056 | 0 | 39 |
| Little Missouri River | 152 | 0 | 65 |

[a] Does not include bottomlands in the lower Missouri River floodplain

**Table 6-13. Acres of woody draw and bottomland vegetation that might be cleared due to reservations in the lower Missouri, Milk, and Little Missouri River subbasins**

| Subbasin | Consumptive Use | Alternative<br>Instream | Combination |
|---|---|---|---|
| Lower Missouri River[a] | 40 | 0 | 4 |
| Milk River | 42 | 0 | 42 |
| Little Missouri River | 16 | 5 | 13 |

[a] Does not include bottomlands in the lower Missouri River floodplain which are summarized in Tables 6-14 and 6-15.

**Table 6-14. Changes in acreage of major vegetation types in the Missouri River bottomlands below Fort Peck Dam for the each alternative (figures in parentheses denote net changes in acres)**

| | Vegetation/Land Use | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Nonirrigated | | | | | | | |
| Alternative | Irrigated | Grain | Hay | Woodland | Mixed prairie | Shrub/ scrub | Prairie | Marsh | Urban |
| Existing Conditions | 43,013 | 62,391 | 5,254 | 26,599 | 19,073 | 8,799 | 19,762 | 2,047 | 898 |
| Consumptive Use | 69,142<br>(+26,129) | 46,745<br>(-15,646) | 3,772<br>(-1,482) | 22,865<br>(-3,734) | 16,531<br>(-2,542) | 8,447<br>(-352) | 17,447<br>(-2,315) | 2,034<br>(-13) | 898<br>(0) |
| Combination | 64,717<br>(+21,704) | 50,478<br>(-11,913) | 3,905<br>(-1,349) | 23,119<br>(-3,480) | 16,664<br>(-2,409) | 8,535<br>(-264) | 17,522<br>(-2,240) | 2,036<br>(-11) | 898<br>(0) |
| Instream | 47,940<br>(+4,927) | 60,045<br>(-2,346) | 4,495<br>(-759) | 26,382<br>(-217) | 18,657<br>(-416) | 8,741<br>(-58) | 18,670<br>(-1,092) | 2,046<br>(1) | 898<br>(0) |

**Table 6-15. Vegetation changes that would occur with the development of proposed irrigation projects in the Missouri River bottomlands below Fort Peck for each alternative**

| | Vegetation/Land Use (percent) | | | | |
|---|---|---|---|---|---|
| Alternative | Agricultural[a] | Urban | Woodlands | Shrub/ scrub | Prairie and mixed prairie[b] |
| Existing Conditions | 58 | 1 | 14 | 5 | 22 |
| Consumptive Use | 64 | 1 | 12 | 4 | 19 |
| Combination | 63 | 1 | 12 | 5 | 19 |
| Instream | 60 | 1 | 14 | 5 | 21 |

[a] includes irrigated and nonirrigated cropland

[b] also includes marsh

## OTHER IMPACTS

Irrigation projects also would affect native plants as land is disturbed and cleared to make way for pipelines, canals and diversion structures. Such impacts would be greatest under the Consumptive Use Alternative, followed by the Combination Alternative. Much lesser impacts would occur under the Instream Alternative.

Summertime streamflows would be substantially reduced in the Poplar River, East Fork Poplar River, Middle Fork Poplar River, West Fork Poplar River, Little Beaver Creek, Boxelder Creek, and Little Missouri River as water is pumped for the irrigation projects. Because shallow floodplain aquifers are often closely connected to a stream, reduced streamflows could lower water tables. This would stress riparian plant communities along the stream.

Streamflow reductions along the Missouri river would be small relative to existing streamflows. It is unlikely reparian vegetation would be affedted as a result.

Riparian areas along small stream channels could be adversely affected as a result of water diversion for water-spreading and small storage projects. Soil moisture in the riparian areas along these small streams is replenished by spring floods, which would be reduced by the projects. Shallow-rooted wet meadow sedges, rushes, and grass could suffer and be replaced by grasses and forbs that are adapted to drier conditions.

Municipal reservations also would disturb plant communities when wells, diversion structures, water storage tanks, and pipelines are constructed. Overall, these impacts would be minor under all alternatives.

**Sensitive Plants:** Sensitive plants that grow in areas where reservation projects are proposed have been listed in Table 4-8 in Chapter Four. Field surveys have not been conducted to ascertain if any of these plants grow within the project sites. One sensitive plant species, the Nannyberry (Virbum lentago), has been located near project CBI-16.

**Noxious Weeds:** Noxious weeds could become established when land in native vegetation is converted to cropland or disturbed for canal and pipeline routes. Because the reservoir created by the proposed Battle Creek Reservoir (project BL-181) would be drawn down substantially each irrigation season, weeds could invade the exposed shorelines and mudflats. Weeds could spread farther when water contaminated with weed seeds is released from the reservoir and subsequently distributed by irrigation systems downstream. Similar problems could occur, but on a much smaller scale, for the other small reservoir projects in the Milk River subbasin under the Consumptive Use Alternative. Weed control might be necessary along the reservoirs and on some project land. Weed invasion also could be a problem in water-spreading projects and on spreader dikes. It is likely that herbicides would be used to control weeds. Herbicides could kill native, nontarget plants.

## WETLANDS

Wetlands could be affected by proposed consumptive use reservations in two ways. First, wetlands could be disturbed directly as they are cleared, plowed, filled, and drained to make land suitable for crop production. Second, wetlands could be disturbed indirectly if water tables are lowered by pumping surface water or groundwater.

### SHERIDAN COUNTY GROUNDWATER AREA

Wetlands inventoried by USFWS in 1983 are located within many of the sprinkler irrigation projects being considered in the Sheridan County Groundwater Area (Appendix F). Developing these projects could disturb wetlands to the point that a 404 Permit would be required from the Corps of Engineers, and farm program benefits could be lost due to the "Swampbuster" provisions of the 1990 Food, Agriculture, Conservation, and Trade Act. Consequently, farmers may choose not to develop a project that could disturb a wetland in order to protect their federal farm program benefits. SCS is responsible for the final determination of wetlands with regard to the Swampbuster provisions.

Irrigation development would not be possible on some land covered by wetland easements or owned by USFWS (Appendix F).

Pumping groundwater for irrigation would cause a cone-shaped depression of water levels near each well. With development of many projects, regional water tables could be lowered. These processes are explained in more detail in the Groundwater section.

The Sheridan County Groundwater Area has numerous lakes, ponds, and marshes, of which as many as 85 percent are directly connected to the water table. Consequently, any lowering of the water table, due to either the pumping of a nearby well or the combined effects of pumping many wells, could affect the levels of these surface water bodies (see Groundwater section for further discussion). Reduced water levels would decrease the surface areas of these lakes, ponds, and marshes and also that of the moist fringe areas surrounding them. Plant species adapted to drier conditions would then invade previously moist areas. Neither the Swampbuster provisions nor 404 Permit process would protect wetlands from the effects of lowered water levels. However, provisions of the Endangered Species Act, if enforced, could result in prosecution of persons responsible for development of projects that adversely affect habitat of the piping plover.

The irrigated area of many projects includes wetlands. This could enlarge wetlands that are not directly connected to the water table and prolong the time the wetlands remain saturated. Water quality in such wetlands could degrade if poor quality groundwater is pumped or salts are leached from surrounding soils by irrigation.

As indicated in Appendix F, most of the proposed projects in the Sheridan County Groundwater Area contain small, intermittent, seasonally flooded wetlands. During dry years, some of these wetlands are not flooded. Many of these wetlands probably have been cultivated and lost their wetland values.

Impacts to wetlands could be greatest under the Grant All and Partial Granting alternatives. The Sheridan County Conservation District's proposed management plan may not protect wetlands adequately under the Grant All Alternative. The Partial Granting Alternative, although it allows relatively little irrigation development with reserved water, would not reserve enough water to protect wetlands from appropriation of water through the water permitting process. Impacts to wetlands would probably be lowest under the Coordinated Groundwater Development Alternative because groups with diverse interests would be responsible for managing the groundwater resources.

### LOWER MISSOURI RIVER SUBBASIN

USFWS has not completed its inventory of wetlands in most of the lower Missouri River subbasin. However, wetland inventory maps are available for the Missouri River floodplain below Brockton. According to these maps, most of the irrigation projects that would divert water from the Missouri River below this point contain at least small wetlands (Table 6-16). For the most part, these wetlands are seasonally flooded, or briefly flooded during the growing season most years. Most contain herbaceous plants, but some are wooded. It is likely that many of the proposed irrigation projects above Brockton also include wetlands.

Clearing, plowing, filling, and leveling land for irrigation development would destroy many wetlands. Such impacts would be greatest under the Consumptive Use Alternative, somewhat less under the Combination Alternative, and much less under the Instream Alternative. Due to the Swampbuster provisions, farmers would risk losing farm subsidies if they developed a project on a wetland not farmed before 1985.

In the Poplar River drainage, a small wet area is located in the south unit of project DA-71, which is included in the Consumptive Use and Combination alternatives. Projects DA-251 and DA-252, which are included in the Combination and Consumptive Use alternatives, would divert water that supports wetland-type plants downstream.

In the Poplar River drainage, Ducks Unlimited and USFWS have been cooperating to develop the International Marsh Waterfowl Production Area. This waterfowl production area would be located along the Montana/Saskatchewan border, approximately 13 miles north of Scobey in Daniels County. It contains several shallow wetland areas and a 180-acre wetland with a capacity of about 95 acre-feet. The project involves the reestablishment of a low earth dam that was breached many years ago. Ducks Unlimited designed and will build the dam, which will inundate 771 surface acres of marsh on both sides of the international border. An additional 1,100 acre-feet will be impounded for a total capacity of 1,193 acre-feet (Ladd 1993). Proposed reservations further downstream may reduce the amount of water available for this project.

### MILK AND LITTLE MISSOURI RIVER SUBBASINS

Wetland inventories are not available for land proposed for development in these subbasins. During its field investigations, DNRC found possible wetlands in abandoned meander channels in projects VA-211 and VA-261 along the Milk River. Both projects are included in the Combination and Consumptive Use alternatives. Marshy spots and wetland-type vegetation were found in portions of the Little Missouri River subbasin projects LB-041, LB-

**Table 6-16. Summary of wetlands inventoried by USFWS within proposed irrigation projects near the Missouri River below Brockton**

| Project | Wetland acres | Wetland types[a] | Alternatives[b] |
|---|---|---|---|
| CBI-10 | 15 | PEMA, PEMC | CU,C |
| CBI-11 | 22 | PEMA, PABF, PEMC | CU,C |
| CBI-12 | 14 | PEMA, PEMCx, PSSA | CU |
| CBI-13 | 48 | PEMC, PEMCx, PEMA, PABF, PFOA | CU |
| CBI-14 | 1 | PEMA | CU,I,C |
| CBI-15 | 5 | PEMA, PEMC | CU,C |
| CBI-16 | 1 | PEMA, PEMC | CU,C |
| CBI-17 | 1 | PEMA | CU,I,C |
| CBI-19 | 6 | PEMA, PEMC | CU,I,C |
| CBI-20 | 92 | PEMA, PEMC, PSSC | CU |
| CBI-21 | 1 | PEMC | CU,C |
| RI-05 | 13 | PEMA, PEMC, PSSA | CU,C |
| RI-06 | 40 | PEMA, PSSA | CU,C |
| RI-07 | 40 | PEMA, PEMC, PSSA | CU |
| RI-09 | 33 | PEMA, PEMC, PSSA | CU,C |
| RI-10 | 25 | PEMA, PEMC, PFOC, PFOA | CU,I,C |
| RI-11A | 2 | PEMA | CU,C |
| RI-11 | 56 | PEMA, PEMC, PSSA, PFOA | CU,I,C |
| RI-12 | 5 | PEMA | CU,I,C |
| RI-13 | 26 | PEMA, PUSA | CU,C |
| RI-14 | 70 | PEMA, PSSA, PEMC, PEMCx, PABF | CU,C |
| RI-15 | 42 | PEMA, PEMC, PFOC, PSSA | CU,C |
| TOTAL | 558 | | |

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[a] Wetlands were classified based on the Cowardin System (Cowardin et al. 1979). The system as it applies to these wetlands is coded as follows:

System (first letter):
- Palustrine (P) - vegetated non-tidal wetlands

Classes (second and third letters):
- Aquatic bed (AB) - contains beds of aquatic plants
- Emergent (EM) - dominated by non-woody plants
- Forested (FO)
- Scrub-shrub (SS)
- Unconsolidated shore (US) - river shorelines

Water Regime (fourth letter)
- Temporarily flooded (A) - only flooded for brief periods most years
- Seasonally flooded (C) - flooded seasonally for more extended periods
- Semipermanently flooded (F) - flooded for most of the growing season

Modifiers (fifth letter, if present)
- Excavated (x)

[b] CU = Consumptive Use Alternative
I = Instream Alternative
C = Combination Alternative

151, LB-171, CT-171, and CT-262, which are included in the Consumptive Use and Combination alternatives; and projects WI-74, WI-75, WI-151, which are included only in the Consumptive Use Alternative. Project CT-171 also contains a small pond. Construction of spreaders and dikes and land leveling for water-spreading projects could fill and destroy small wetlands at these and possibly other project sites.

## LAND USE

### LOWER MISSOURI RIVER SUBBASIN

Land use would change the most where cropland, pastures, or bottomland are converted to irrigated cropland. To prepare land for irrigation, some previously nonirrigated land would have to be cleared of trees or brush and leveled (see Vegetation, Wildlife, and Soils). Most projects would require construction of a pipeline or canal from the point of diversion to the point of use. Electric lines would be used to supply power to the pumps for most projects.

Pipelines, canals, and electric lines may cross land owned by persons who would not benefit from the project. Table 6-6 lists larger pipelines and canals that would be constructed to the larger proposed irrigation projects. Most proposed canals or pipelines would have little impact if located along existing roads, utility corridors, or fencelines. Impacts also could be avoided by locating away from residences, commercial areas, or recreation sites. Construction activities also might cause short-term effects, such as increased noise, traffic, dust, and erosion. Impacts might be higher where longer canals would be needed and would be higher if projects conflict with parks, recreation areas, irrigated land, mineral areas, or wildlife.

Conflicts between proposed pipelines and canals and parks, recreation areas, irrigated land, mineral areas, or wildlife cannot be identified without additional field investigation.

Additional information on the location of proposed powerlines would be necessary to fully assess land use impacts. Table 6-17 lists proposed irrigation projects with electric lines that would be 5 or more miles long. These larger lines have the greatest probability of causing high land use impacts. Land use impacts generally can be minimized by proper electric line siting. Impacts from electric lines would be more acceptable where located on the irrigators' property.

Most of the proposed irrigation projects would irrigate less than 500 acres and would have little effect on local transportation. In some locations, low-standard roads may have to be abandoned or rerouted. On larger projects, canal or pipeline construction might cause short-term transportation delays during construction. Projects of 2,500 acres or more can cause small increases in local traffic, particularly during the haying season.

Because overall irrigated cropland acreage trends are stable or decreasing (USDA 1989), the increased irrigated cropland acreage resulting from these reservations may displace existing irrigated cropland, which presumably would return to dryland uses. This displacement would be more noticeable for alfalfa cropland acreage. As part of an integrated ranching operation, alfalfa is assumed to be the most profitable crop to be irrigated with reserved water (see Economics). Alfalfa production from existing irrigated land is expected to continue to increase substantially from the present average rate of 3.0 tons per acre to 3.9 tons per acre (31 percent increase) in the year 2020 (Figure 6-14). Virtually all Montana alfalfa is produced for cattle feed.

**Table 6-17. Lengths of electric lines required for lower Missouri River basin projects that would need 5 miles or more of lines**

| | Alternative | | |
|---|---|---|---|
| | Consumptive Use | Instream | Combination |
| Roosevelt County CD | | | |
| CBI-17 | 8.0 | 8.0 | 8.0 |
| CBI-20 | 5.0 | — | — |
| **TOTAL** | **13.0 (miles)** | **8.0 (miles)** | **8.0 (miles)** |

Municipal water reservations generally would require development of a pumping site and a pipeline to the municipal water treatment facility. In most cases, the reservation development would involve limited short-term construction activities with most of the affected land returning to its former condition.

Instream flow reservations would generally have little or no effect on existing or future land uses. On some streams, instream reservations might constrain water rights for future irrigation.

### LOWER MISSOURI RIVER SUBBASIN

Under the Consumptive Use Alternative, approximately 45,698 acres is proposed to be irrigated with reserved water, increasing total subbasin irrigated acreage by 102 percent. Projects under this alternative would convert approximately 34,940 acres of cropland and 10,758 acres of pasture/rangeland to irrigated cropland. Of these 34,940 existing cropland acres, 5 percent are currently irrigated when water is available. Approximately 300 acres of VA-03, proposed by the Valley County Conservation District, already have a water reservation granted to VAS-01 during the upper Missouri River water reservation process.

Under the Combination Alternative, approximately 28,532 acres of land would be irrigated with reserved water, increasing total subbasin irrigated acreage by 64 percent. Projects under this alternative would convert approximately 18,815 acres of cropland and 9,717 acres of pasture/rangeland to irrigated cropland. Of the 18,815 existing cropland acres, 7 percent are currently irrigated when water is available.

Under the Instream Alternative, approximately 6,846 acres of land would become irrigated cropland, increasing total subbasin irrigated acreage by 15 percent. Projects under this alternative would convert approximately 3,414 acres of cropland and 3,432 acres of pasture/rangeland to irrigated cropland. Of the 3,414 existing cropland acres, 4 percent currently are irrigated when water is available.

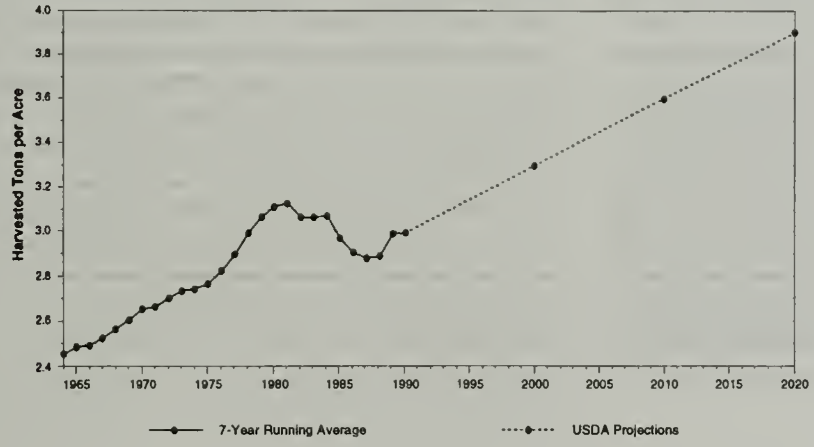
### MILK RIVER SUBBASIN

Under the Consumptive Use Alternative, approximately 7,118 acres would be converted to full service irrigated land using reserved water, increasing total subbasin irrigated acreage by 3.3 percent. These projects would convert approximately 6,835 acres of cropland and 283 acres of pasture/rangeland to full service irrigated cropland. Of the 6,835 existing cropland acres proposed for water reservations, 91 percent are currently irrigated when water is available.

Under the Combination Alternative, approximately 927 acres of land would be irrigated with reserved water, increasing total subbasin irrigated acreage by 0.4 percent. Projects under this alternative would convert approximately 715 acres of cropland and 212 acres of pasture/rangeland to irrigated cropland. Of the 715 cropland acres, 32 percent are currently irrigated when water is available.

Under the Instream Alternative, approximately 144 acres of land would be irrigated with reserved water, increasing total subbasin irrigated acreage by 0.07 percent. Project VA-171 would convert approximately 144 acres of dryland cropland to irrigated cropland.

**Figure 6-14. Irrigated alfalfa yield trends and projection in Missouri River basin counties**



Sources: Montana Crop and Livestock Reporting Service 1964 through 1989
USDA 1989

### LITTLE MISSOURI RIVER SUBBASIN

Under the Consumptive Use Alternative, 78 projects would irrigate approximately 4,571 acres with reserved water, increasing total subbasin irrigated acreage by 32 percent. Projects under this alternative would convert approximately 1,765 acres of cropland and 2,806 acres of pasture/rangeland to irrigated cropland. None of the 1,765 cropland acres are currently irrigated.

Under the Combination Alternative, 47 projects would irrigate approximately 2,647 acres of land, increasing total irrigated acreage in the subbasin by 18 percent. These projects would convert approximately 389 acres of cropland and 2,258 acres of pasture/rangeland to irrigated cropland. None of the 389 cropland acres are currently irrigated.

Under the Instream Alternative, approximately 373 acres of land would be irrigated by four projects, increasing total subbasin irrigated acreage by 3 percent. These projects would convert approximately 33 acres of cropland and 340 acres of pasture/rangeland to irrigated cropland. None of the 33 cropland acres are currently irrigated.

### SHERIDAN COUNTY GROUNDWATER AREA

Under the Grant All Alternative, up to 306 projects could irrigate as much as 42,600 acres, increasing the county's irrigated cropland acreage by 540 percent. Projects under this alternative could convert up to 38,020 acres of cropland and 4,580 acres of pasture/rangeland to irrigated cropland. Of the 38,020 cropland acres, an estimated 32 percent are currently enrolled in the Conservation Reserve Program or have recently been converted to pasture. Irrigation uses would be precluded or highly limited on land with wetland easements (see Appendix F).

The proposed Sheridan County depletions could reduce lake levels in Medicine Lake National Wildlife Refuge (see Groundwater). Medicine Lake is managed for waterfowl production, having state water right claims for this use. It is uncertain whether USFWS will assert a federal reserved right for the wilderness (Williss 1994). Under the Grant All Alternative, lake level reductions could conflict with both of these refuge land uses, depending upon the nature and locations of the water level drawdowns. Under the Partial Granting and Coordinated Groundwater Development alternatives, impacts to lake levels would not be noticeable.

Under the Partial Granting Alternative, approximately 2,500 acres of land would be irrigated, increasing total county irrigated acreage by 32 percent.

Under the Coordinated Groundwater Development Alternative, approximately 5,600 acres of land would be irrigated with reserved water, increasing total county irrigated acreage by 71 percent.

## FISHERIES AND AQUATIC HABITAT

Reduced streamflow can decrease the habitat available to fish and aquatic organisms eaten by fish, resulting in fewer and smaller fish in a stream. The effect of reduced streamflow can be illustrated by comparing fish populations above and below major diversions or by comparing populations before and after droughts. On the upper Musselshell River, the 1985 drought reduced brown trout populations by one-half near the Selkirk fishing access. This population decline was most noticeable in younger fish, which declined 72 to 93 percent (DFWP undated[c]). In another portion of the Musselshell River, fish populations below the Deadman's Basin supply canal are about one-third those above the diversion (Vaughn and Fredenberg 1984). A large portion of the Musselshell River is diverted throughout much of the year into the Deadman's Basin supply canal.

Tennant (1976), with the assistance of state fisheries biologists, conducted detailed field studies on 11 streams east of the Continental Divide in three states, including Montana, and concluded that the condition of aquatic habitat varies with remarkable uniformity in proportion to the average annual flow. He found that excellent to outstanding habitat for most aquatic life forms would be maintained when a flow equalling 60 percent of the average annual flow was maintained instream. Tennant recommended at least 30 percent of average annual flow be retained instream to preserve good survival conditions for most aquatic life forms. The study suggested that 10 percent of the average annual flow was minimum for short-term survival of most aquatic life. Although these generalizations may not apply in all situations, they demonstrate how flows are related to aquatic habitat and fish populations in a general sense. These generalizations also point out that fish may survive for short periods despite low flows, but good survival conditions for aquatic life depend on adequate flow.

On most streams discussed in this chapter, not enough information is available to establish the exact relationship between flow rates and fish populations. Many factors interact to influence fish populations, including fishing pressure, reproductive success, and habitat conditions. These factors interact in complex ways, allowing fish populations to increase or decline.

In this analysis, two approaches were used to determine impacts to fish and aquatic habitat. In coldwater streams that support trout, streamflow rates that are sufficient to maintain water in riffle areas were considered adequate to maintain good habitat conditions. If flows were to decrease as a result of new consumptive uses and fall below these rates, some riffles would begin to dry and habitat would be lost. In streams that support fish that are adapted to warmer, more turbid conditions, such as sauger, northern pike, and channel catfish, the natural low flows that normally occur during summer and winter were considered to be the lowest flow sufficient to provide adequate depth and water movement to help prevent stagnation of the pools.

Other methods are available to estimate instream flow needs. Several are discussed in DNRC 1992; Lamb 1989; Leathe and Nelson 1986; and EA Engineering, Science, and Technology, Inc. 1986.

The methods DFWP used to determine instream flow requests are discussed in Appendix C.

In general, impacts of reduced streamflows would be noticed most on streams where flows are sometimes so low that aquatic habitat is already being adversely affected. In some instances, additional depletions would reduce flows to nothing. As flows are severely reduced, the condition of fish would decline, and some fish could die from increased summer water temperatures, lowered dissolved oxygen levels in summer or winter, and reduced food production. These effects on fish populations could be long term if a cycle of extremely low flows followed by a gradual recovery of the fishery is repeated several times. The fishery could take several years to recover from the effects of a very low-flow year or winter kill. Impacts of additional consumptive water uses would be minor if streamflows are maintained at levels that adequately protect aquatic habitat.

Short-term increases in sediment loads could occur during construction of facilities to divert water for irrigation or municipal water use and could damage aquatic habitat. Sediment from construction can settle out of the water farther downstream, blanketing the stream bottom, clogging spawning beds, and damaging invertebrate populations that serve as food for fish (EPA 1986). Clogging the spaces in spawning bed gravel also can decrease the survival of fish eggs. Proper construction timing and techniques discussed later in this chapter could reduce this sedimentation impact.

Nutrients added to streams as a result of proposed consumptive uses could increase the growth of aquatic plants up to the point where detrimental effects occur. Plants, including algae, produce oxygen during the day but consume it at night. When growth becomes too rapid, large amounts of dissolved oxygen are used at night. This leaves less dissolved oxygen available for fish and other aquatic organisms. Not enough information is available for most streams to determine whether detrimental effects would occur from the addition of nutrients. However, decreasing flow during the summer or adding nutrients to streams that already have low dissolved oxygen levels would adversely affect aquatic life.

Diversion structures could trap and kill fish, especially during periods of low flow when most of the stream or river would be diverted. Proper design of diversion structures could reduce this impact.

Municipal reservations would have only minor effects on aquatic habitat and fish populations.

Instream reservations would help preserve aquatic habitat and fisheries (described in Chapter Four), but would not necessarily prevent new water development. Unappropriated flows in excess of instream reservations (Appendix J) could still be impounded or diverted. Reservation of instream flows would not limit the exercise of existing water rights or offer protection from natural conditions that already cause severe low flows and adversely affect aquatic habitat.

Table 6-18 lists the five storage projects that have been proposed and indicates the likelihood that each would support a fishery. All but project BL-181 on Battle Creek are small projects. As stated in the applications, the purpose of four projects is strictly storage for irrigation. It is unlikely that they would support a fishery over the long term since they would be drawn down in most years. Project BL-181 is in a shallow drainage and would be drawn down yearly. The irrigation storage projects are included only under the Consumptive Use Alternative.

**Table 6-18. Likelihood of proposed storage projects supporting a fishery under the Consumptive, Instream, and Combination alternatives**

| Location of proposed storage project | Alternative | | |
|---|---|---|---|
| | Consumptive Use | Instream | Combination |
| LI-241 - Lost Coulee | small | — | — |
| BL-131 - Tributary Black Coulee | small | — | — |
| BL-171 - Link Coulee | small | — | — |
| BL-181 - Battle Creek | small | — | — |
| Chinook | moderate | moderate | moderate |

— indicates the project is not included under that alternative

## IMPACTS OF THE CONSUMPTIVE USE, INSTREAM, AND COMBINATION ALTERNATIVES

### LOWER MISSOURI RIVER SUBBASIN

Pallid sturgeon, an endangered species, inhabit the Missouri River below Fort Peck Dam. Habitat requirements of this species have not been precisely defined, and the effects of the proposed reservations for consumptive uses are not precisely known. However, flow reductions and aquatic habitat losses would be in addition to those caused by construction of Fort Peck Dam.

Two projects, VA-01 and VA-02, would have a slight effect on flows in a side channel important to rainbow trout spawning and rearing just below Fort Peck Dam. Together, these projects would reduce flows in the river by about 10.5 cfs during July. Flows of roughly 250 cfs are needed in the side channel to maintain riffle habitat, and about 7,800 cfs are needed in the main channel to maintain 250 cfs in the side channel. Average monthly flows of 7,800 cfs are equalled or exceeded slightly more than 8 years in 10 in July, and this would not change substantially as a result of the proposed reservations. The flow reductions of 10.5 cfs would be in addition to the hourly changes in flow caused by the Corps of Engineers releases of water from Fort Peck Dam (see Water Quantity and Distribution).

Just above the mouth of the Milk River, the proposed reservations would reduce flows in the Missouri River by an average of less than 27 cfs in July. Such reductions would be almost unnoticeable in a river the size of the Missouri River.

Riffles are important as producers of aquatic invertebrates that fish use for food, so DFWP studied the Missouri River between the mouth of the Milk River and the Montana/North Dakota border to determine flows necessary to maintain this habitat. These studies (Frazer 1985, 1987; Gardner and Stewart 1987) show that flows of 7,000 cfs would maintain optimal riffle habitat in all three riffles investigated, 5,000 cfs would maintain riffle habitat in two of the three riffles, while flows of 4,200 would maintain habitat in only one of the three riffle areas examined. Table 6-19 shows that the proposed reservations and the reservations already granted in the upper basin proceeding would decrease flows in the lower Missouri reach only slightly. Flow reductions would be greatest in July. In July, flows of 7,000 cfs are currently equalled or exceeded about 92 percent of the time. Under the Consumptive Use Alternative, July flows of 7,000 cfs would be exceeded about 84 percent of the time. Reductions in flow and riffle habitat would be greatest under the Consumptive Use Alternative and least under the Instream Alternative.

In the Missouri River below the confluence with the Milk River, flows of about 11,000 to 11,500 cfs are necessary to maintain about 2 feet of water over the rocky reef habitat used for sauger spawning and incubation during late May and June. Only eight such spawning sites are known on this reach of river. As shown in Table 6-19, such flows are presently equaled or exceeded roughly once in every 4 to 5 years. Flows and the availability of spawning habitat would decrease slightly under all alternatives with development of the proposed reservations and those granted in the upper basin. Spawning habitat loss would be greatest under the Consumptive Use Alternative and least under the Instream Alternative.

**Table 6-19. Changes in flow affecting aquatic habitat in the Missouri River near the Montana-North Dakota border under the Consumptive Use, Instream, and Combination alternatives**

| Approximate flows(cfs) necessary to maintain aquatic habitat in the Missouri River at the Montana-North Dakota border during certain periods[a] | | | Percent of the time flow is equaled or exceeded under existing conditions Alternative[b] | | Percent of the time flow is equaled or exceeded under Consumptive Use Alternative[b] | | Percent of the time flow is equaled or exceeded under Instream Alternative[b] | | Percent of the time flow is equaled or exceeded under Combination Alternative[b] | |
|---|---|---|---|---|---|---|---|---|---|---|
| Purpose | Period | Flow (cfs) | Period | Percent | Period | Percent | Period | Percent | Period | Percent |
| Maintain habitat for sauger spawning and incubation | May 11 - June 30 | 11,500 | May | 21 | May | 18 | May | 19 | May | 19 |
| | | | June | 27 | June | 25 | June | 26 | June | 25 |
| Maintain main channel riffle habitat | July 1 - May 10 | 7,000 | July | 92 | July | 84 | July | 91 | July | 85 |
| | | August | 72 | August | 70 | August | 71 | August | 71 | |
| | | | September | 69 | September | 66 | September | 66 | September | 66 |
| | | | October | 39 | October | 36 | October | 36 | October | 36 |
| | | | November | 45 | November | 42 | November | 42 | November | 42 |
| | | | December | 100 | December | 100 | December | 100 | December | 100 |
| | | | January | 100 | January | 100 | January | 100 | January | 100 |
| | | | February | 100 | February | 100 | February | 100 | February | 100 |
| | | | March | 98 | March | 95 | March | 95 | March | 95 |
| | | | April | 69 | April | 68 | April | 70 | April | 70 |
| | | | May | 65 | May | 61 | May | 64 | May | 64 |

[a] SOURCE DFWP 1991

[b] Includes flow reductions resulting from exercise of reservations granted in the upper Missouri River water reservation process

**Poplar River Drainage**: In the Poplar River drainage, return flows from proposed irrigation projects would increase flows slightly in October and November. Flows would not change during the winter months. Flows would decrease during the summer unless the Tribes enforce their instream flow rights on the Fort Peck Indian Reservation. About 11 cfs is the minimum thought necessary to protect aquatic habitat in the river above the Fort Peck Indian Reservation. During July, under the Consumptive Use Alternative, flows would cease in the Poplar River above the Fort Peck Indian Reservation in a very dry year (about 1 year in 10) (Table 6-20). During August, flow would cease in the river in dry and very dry years. Under existing conditions, August flow in the Poplar River in dry and very dry years is estimated to be 1 cfs. Although the fish inhabiting the river are adapted to occasional low summer flows, more frequent cessation of flow in conjunction with high summer temperatures and drawdown in some of the pools would further stress the aquatic habitat and fish.

About 3.7 to 4 cfs is thought necessary for aquatic habitat in the West Fork of the Poplar River north of the reservation boundary. Flows in the West Fork of the Poplar River could drop from 0.7 to 0.5 cfs during August in dry years under the Consumptive Use Alternative if downstream instream flow rights are not enforced. At present, August flows cease less than 1 year in 10. More frequent cessation of flow would stress aquatic habitat and fish inhabiting the stream.

On the East Fork of the Poplar River, flows would be reduced from 3 to about 2.3 cfs in 2 years in 10 under the Consumptive Use Alternative. Roughly 4 cfs is thought to be necessary in this reach to protect aquatic habitat during the summer.

On the Poplar River near the Fort Peck Indian Reservation, aquatic habitat would be affected to a lesser degree under the Combination Alternative than under the Consumptive Use Alternative (Table 6-20). Flows of about 11 cfs would provide a small amount of water flowing through riffles and pools to maintain aquatic habitat. Under the Combination Alternative, flows would fall to 3.9 cfs in July of dry years and cease in August of dry years. On the East Fork of the Poplar River, flows would be reduced by about 0.4 cfs in July and 0.2 cfs in August under the Consumptive Use and Combination alternatives. Flows would cease during August in dry and very dry years and further stress aquatic habitat.

Flows would not change on the East Fork of the Poplar River under the Combination Alternative.

Under the Instream Alternative, new diversions from the Poplar River and its forks would not be allowed when flows fall below those DFWP found necessary for fish and aquatic habitat.

**Redwater River Drainage:** In the Redwater River drainage, flows and aquatic habitat would not change substantially under any of the alternatives. The only reservation sought for consumptive uses in this drainage is for the town of Circle. It would withdraw water from a deep aquifer and have negligible effect on flows in the Redwater River.

### MILK RIVER SUBBASIN

**Milk River:** For each of the locations examined by DNRC, except Dodson, flows in the Milk River would generally increase, and aquatic habitat would improve under the Consumptive Use Alternative due to BUREC's Virgelle Diversion for which a water reservation was granted as part of the upper Missouri River water reservation process. BUREC's Virgelle Diversion would account for most of the increases above Dodson. Return flows from existing irrigation projects below this point would account for most of the increases in the lower portion of the river. Some return flows from project VAS-1 (approved by the Board in the upper basin proceeding) would reach the lower Milk River below Nashua.

In theory, the Battle Creek (BL-181) project could affect aquatic habitat anywhere in the Milk River drainage through water exchanges. If the Battle Creek project is operated as proposed, it could improve summer flows and habitat in the Milk but would reduce spring flows.

Under the Instream and Combination alternatives, flows would be slightly greater than under the Consumptive Use Alternative. Most of the year at most locations, flows would increase, but again, this is mostly due to the reservation granted by the Board for BUREC's Virgelle Diversion project in the upper Missouri River basin water reservation proceeding.

**Battle Creek:** Two reservations for irrigation storage projects are proposed in the Battle Creek drainage—BL-171, a small project on Link Coulee, and BL-181, a larger project on Battle Creek. Link Coulee contains an ephemeral stream that does not support a fishery. Battle Creek supports a diverse warm water fishery.

**Table 6-20. Changes in flow affecting aquatic habitat in portions of the Poplar River Drainage.**

| Stream | Mimimum flow to protect aquatic habitat (cfs)[a] | Existing flow (cfs)[b] during dry and very dry years (very dry in ())[cd] | | Flow (cfs) under the Consumptive Use Alt. in dry and very dry years | | Flow (cfs) under the Instream Alt. in dry and very dry years | | Flow (cfs) under the Combination Alt. in dry and very dry years | |
|---|---|---|---|---|---|---|---|---|---|
| | | July | August | July | August | July | August | July | August |
| Poplar River at reservation boundary | 11 | 6.0<br>(3.0) | 1.0<br>(1.0) | 2.6<br>(0) | 0<br>(0) | 5.9<br>(2.9) | 6.0<br>(3.0) | 4.3<br>(1.3) | 0.2<br>(0.2) |
| West Fork Poplar River at reservation boundary | 4 | 3.0<br>(1.0) | 0.7<br>(0.7) | 2.6<br>(.6) | 0.5<br>(0.5) | 3.0<br>(1.0) | .7<br>(.7) | 3.0<br>(1.0) | 0.7<br>(0.7) |
| East Fork Poplar River at mouth | 4 | 3.0<br>(3.0) | 3.0<br>(3.0) | 2.3<br>(2.3) | 2.8<br>(2.8) | 3.0<br>(3.0) | 3.0<br>(3.0) | 3.0<br>(3.0) | 3.0<br>(3.0) |
| Middle Fork Poplar River above confluence with East Fork | 2 | 1.0<br>(0.5) | 0.2<br>(0.2) | .3<br>(0) | .1<br>(.1) | 1.0<br>(.5) | .2<br>(.2) | .6<br>(.1) | .1<br>(.1) |

[a] source DFWP 1991
[b] source USGS undated
[c] flows in a dry year are exceeded in 8 years out of 10
[d] flows in a very dry year are exceeded in 9 years out of 10

Under the Consumptive Use Alternative, flows at the mouth of Battle Creek generally would decrease during the spring and increase the rest of the year. Flow would remain at 0 cfs during the winter months of dry years (see Appendix D). Summer flows would generally improve. This would help aquatic habitat, but high spring flows necessary for channel maintenance would decrease (see Stream Channel Form for further discussion). About 5 cfs is thought sufficient to maintain aquatic habitat in Battle Creek during the summer and 2 cfs during the winter, but flows are less than this now during dry and very dry years.

Aquatic habitat in Battle Creek would not change under the Instream and Combination alternatives because the storage projects would not be built. Aquatic habitat also could be reduced on several other tributary streams in the Milk River drainage. Most are ephemeral and are not likely to support fish. However, Lost Coulee is spring fed.

### LITTLE MISSOURI RIVER SUBBASIN

**Little Missouri River:** Under the Consumptive Use Alternative, flows in the Little Missouri River would increase slightly during the fall and into the winter, which would improve aquatic habitat conditions slightly during these times. Spring and summer flows would decrease, however, and flows would cease more often. During 1 year in 10, flow in the river would cease altogether in August and September (see Appendix D). Lack of flowing water would further stress aquatic habitat during these months, but game fish may still survive in the larger pools. Small riffles between pools would be dry. Pool size and volume would decrease with the greatest reductions occurring in pools near diversion sites for projects CT-131, CT-241, CT-191, and CT-11. Effects would be about the same under the Combination Alternative as under the Consumptive Use Alternative. Impacts would be slight under the Instream Alternative.

Table 6-21 indicates tributary streams in the Little Missouri River drainage, where water-spreading projects are proposed that could affect aquatic habitat under the three alternatives.

**Boxelder Creek Drainage:** Flow reductions in this drainage under the Consumptive Use Alternative would probably not be great enough to substantially reduce the spring sauger spawning run in most years. From April to June, average flows of 171 to 246 cfs would be reduced by about 3 cfs or less. However, during the summer in very dry years when flows are now less than approximately 3 cfs, aquatic

**Table 6-21. Streams in the Little Missouri River drainage where adverse effects to aquatic habitat might result from the Consumptive Use, Instream, and Combination alternatives.**

| | Alternative | | | |
|---|---|---|---|---|
| | Consumptive Use | Instream | Combination | |
| Stream | Project | Project | Project | Remarks |
| North Butte Creek | CT-12 | — | — | fathead minnows are common in the creek |
| UT Long Draw | CT-141 | — | CT-141 | ephemeral stream unlikely to support fish, stream is often dry late in year |
| Elkhorn Creek | CT-161 | — | CT-161 | ephemeral stream unlikely to support fish, stream is often dry late in year |
| UT Elkhorn Creek | CT-162 | — | CT-162 | ephemeral stream unlikely to support fish, stream is often dry late in year |
| Cottonwood Creek | CT-181 | — | CT-181 | ephemeral stream unlikely to support fish, stream is often dry late in year |
| UT Beaver Dam Creek | CT-243 | — | CT-243 | ephemeral stream unlikely to support game fish |
| North Fork Beaver Dam Creek | CT-244 | — | CT-244 | ephemeral stream unlikely to support game fish |

UT means unnamed tributary
— indicates a project is not included in the alternative

habitat would be further stressed. Some isolated pools could provide habitat for fish, but small riffles between pools would be dry. Flows would cease about 1 year in 10 during July, August, and September. Projects diverting flow directly out of the stream channel (CT-121, CT-221, CT-251, CT-370, and CT-380) would decrease water levels of standing pools in dry years. Increases in flow and benefit to aquatic habitat from return flows during the fall and winter would be negligible.

Under the Combination Alternative, impacts would be similar though slightly less than under the Consumptive Use Alternative. Projects CT-121, CT-370, and CT-380 would not pump water from pools in the creek.

Impacts under the Instream Alternative would be slight.

Table 6-22 indicates tributary streams in the Boxelder Creek drainage where aquatic habitat could be affected.

**Little Beaver Creek Drainage:** Flow reductions in this drainage under the Consumptive Use Alternative probably would not be great enough to reduce the spring channel catfish spawning run substantially in most years. From May to July, median flows of 15 to 53 cfs would be reduced by about 3 cfs or less. However, during the summer in very dry years, flows would be at or very near zero, and habitat would be further stressed. Flows would cease about 2 years in 10 during September and be only 0.1 cfs during August. Projects diverting flow directly out of the stream channel (CT-71 and CT-301) would decrease water levels of standing pools in dry years. There would be no increases in flow or benefit to aquatic habitat from return flows during the fall and winter.

Under the Combination Alternative, impacts would be similar though slightly less than under the Consumptive Use Alternative.

Impacts under the Instream Alternative would be slight.

Table 6-23 indicates tributary streams in the Little Beaver Creek drainage where aquatic habitat could be affected.

**Beaver Creek Drainage:** Flow changes (see Appendix D) associated with alternatives would not substantially alter aquatic habitat at the lower end of Beaver Creek. Proposed projects on tributaries to

**Table 6-22. Streams in the Boxelder Creek drainage where adverse effects to aquatic habitat might result from the Consumptive Use, Instream, and Combination alternatives.**

| | Alternative | | | |
|---|---|---|---|---|
| | Consumptive Use | Instream | Combination | |
| Stream | Project | Project | Project | Remarks |
| Lampkin Gulch | CT-122 | — | — | small ephemeral stream, fish status unknown |
| Sherril Creek | CT-151 | — | CT-151 | small ephemeral stream with standing pools, fisheris status unknown |
| UT Boxelder Creek | CT-152 | — | CT-152 | small ephemeral stream with existing water spreading project, stream often dry late in year and unlikely to support fish |
| Hawknest Creek | CT-153 | — | CT-153 | ephemeral stream that is unlikely to support fish, stream often dry late in year |
| UT Boxelder Creek | CT-154 | — | CT-154 | small ephemeral stream with existing water spreading project, stream often dry late in year and unlikely to support fish |
| Freshwater Draw | CT-171 | — | CT-171 | small, shallow ephemeral stream with wetland vegetation along stream channel, existing dugout pond supports lush emergent vegetation, game fish unlikely in stream channel |
| UT East LO Creek | CT-261 | — | CT-261 | turtles noted in pool behind breached dam, no fish noted |
| UT LO Creek | CT-262 | — | CT-262 | turtles noted in pool behind breached dam, no fish noted |
| UT Boxelder Creek | CT-310 | — | CT-310 | ephemeral stream with dry channel at project site |

UT means unnamed tributary
— indicates a project is not included in an altemative

**Table 6-23. Streams in the Little Beaver Creek drainage where adverse effects to aquatic habitat might result from the Consumptive Use, Instream, and Combination alternatives.**

| | Alternative | | | |
|---|---|---|---|---|
| | Consumptive Use | Instream | Combination | |
| Stream | Project | Project | Project | Remarks |
| UT Little Beaver Creek | CT-291 | — | CT-291 | an ephemeral stream with low potential for game fish |
| UT Little Beaver Creek | CT-293 | — | CT-293 | an ephemeral stream with no fish |
| HS Creek | CT-340 | — | CT-340 | an ephemeral stream with low potential for game fish |
| UT Little Beaver Creek | LB-61 | — | LB-61 | an ephemeral stream with low potential for game fish |
| UT Little Beaver Creek | LB-63 | — | LB-63 | small ephemeral stream with low potential for fish |
| Bonepile Creek | LB-83 | — | LB-83 | ephemeral stream, fish unlikely in stream |
| Mud Creek | LB-141 | — | LB-141 | ephemeral stream, fish unlikely in stream |
| UT Duck Creek | LB-151 | — | LB-151 | streambed is marshy in spots, game fish unlikley |
| UT Dugout Creek | LB-181 | — | LB-181 | dry streambed, no fish present |
| UT Dugout Creek | LB-182 | — | LB-182 | ephemeral stream, fish unlikely in stream |

UT means unnamed tributary
— indicates a project is not included in an altemative

**Table 6-24. Streams in the Beaver Creek drainage where adverse effects to aquatic habitat might result from the Consumptive Use, Instream, and Combination alternatives.**

| | Alternative | | | |
|---|---|---|---|---|
| | Consumptive Use | Instream | Combination | |
| Stream | Project | Project | Project | Remarks |
| UT Beaver Creek | WI-41 | — | — | small ephemeral stream, fish unlikley |
| UT Beaver Creek | WI-42 | — | — | small ephemeral stream, fish unlikley |
| UT Beaver Creek | WI-43 | — | WI-43 | small ephemeral stream, fish unlikley |
| UT Beaver Creek | WI-61 | — | — | shallow ephemeral stream with no pools or fish |
| UT Beaver Creek | WI-71 | — | WI-71 | small ephemeral stream with low potential for fish, impoundment already exists |
| UT Beaver Creek | WI-72 | — | — | small intermittant stream channel with low potential for fish |
| East Fork Beaver Creek | WI-73 | — | — | a few shallow standing pools on this portion of East Fork, fish unlikely |
| East Fork Beaver Creek | WI-74 | — | — | a few shallow standing pools on this portion of East Fork, fish unlikely |
| UT Beaver Creek | WI-75 | — | — | a few shallow standing pools and is marshy in spots, presence of fish unknown |
| Rattlesnake Creek | WI-92 | — | — | channel dry in summer, fish unlikely |
| UT Beaver Creek | WI-93 | — | WI-93 | grassy and salt crusted streambed, fish unlikley |
| UT Beaver Creek | WI-121 | — | WI-121 | small stream with riparian vegetation, presence of fish unknown |
| Yates Creek | WI-151 | — | — | at project site channel has shallow marshy spots but otherwise goes dry, no fish at project site, may be some farther downstream |
| UT Hay Creek | WI-161 | — | — | grassy drainage, no fish |
| UT Yates Creek | WI-162 | — | — | grassy drainage, no fish |
| Spring Creek | WI-171 | — | — | dry stream, no fish |
| East Fork Beaver Cr. and UT | WI-181 | — | — | a few shallow standing pools on East Fork, fish unlikely |
| UT Beaver Creek | WI-191 | — | — | grassy draw, fish unlikely |
| UT Beaver Creek | WI-192 | — | — | grassy draw, no fish in stream |
| Lame Steer Creek | WI-201 | — | WI-201 | emergent vegetation in shallow standing water, fish unlikely |
| UT Lame Steer Creek | WI-202 | — | WI-202 | emergent vegetation in shallow standing water, fish unlikely |
| UT Beaver Creek | WI-211 | — | WI-211 | dry channel, no fish |
| UT Lame Steer Creek | WI-221 | — | — | small ephemeral stream, no fish |
| UT Beaver Creek | WI-232 | — | WI-232 | small flow in creek, fish pressence unknown |
| UT Beaver Creek | WI-233 | — | WI-233 | channel seeded to grass, no fish |
| Lame Steer Creek | WI-234 | — | WI-234 | fish possible at times from Lamesteer Reservoir |
| UT Beaver Creek | WI-235 | — | WI-235 | grassy stream channel, no fish |
| UT Beaver Creek | WI-236 | — | — | vegetated channel, fish unlikely |
| Duck Creek | WI-237 | — | — | stream characteristics unknown |
| Rattlesnake Creek | LB-11 | — | — | channel dry in summer, fish unlikely |
| Spring Creek | LB-41 | — | LB-41 | wetland vegetation present on intermittent stream, fish unlikely |
| Fork Beaver Creek | LB-161 | — | — | an ephemeral stream with low potential for a fishery |
| UT East Fork Beaver Cr. | LB-171 | — | — | shallow ephermal stream with a few marshy spots, fish unlikely |

UT means unnamed tributary
— indicates a project is not included in an alternative

Beaver Creek could affect local aquatic habitat, but most of these tributaries, ephemeral with little or no flowing or standing water much of the year, are unlikely to support game fish. It is possible that some nongame fish persist in Lamesteer Creek. Table 6-24 describes the aquatic habitat in tributary streams.

### SHERIDAN COUNTY GROUNDWATER AREA

Under the Grant All Alternative, diversions from the aquifers in the Sheridan County Groundwater Area would exceed the average annual flow of Big Muddy Creek near its mouth. Though there is much uncertainty over the timing and exact amounts of streamflow depletions that would occur as a result of these diversions, it is possible that aquatic habitat might be substantially altered. Flows in Lake Creek, a tributary of Big Muddy Creek, also could be affected. Water levels in Medicine Lake and other lakes closely connected to the affected aquifers could drop, as described in the Groundwater section. As water depths decrease, winter kills of fish in Medicine Lake might become more frequent, especially during periods of low precipitation and harsh winters such as those that occurred during the late 1980s and early 1990s.

Under the Partial Granting Alternative, reductions in streamflow and lake water levels would be substantially less than under the Grant All Alternative.

Under the Coordinated Groundwater Development Alternative, reductions in aquatic habitat in Big Muddy and Lake creeks might be slightly larger than under the Partial Granting Alternative but considerably less than under the Grant All Alternative.

## WILDLIFE

Proposed irrigation projects would affect wildlife in several ways. First, wildlife habitat would be altered when native plant communities are plowed under. Reducing streamflows during the summer growing season could stress in-stream and riparian/wetland habitat by lowering groundwater levels within rooting zones of plants adapted to high groundwater tables. Lowering water levels in wetlands could make them unsuitable for breeding or foraging by waterfowl.

Conversion of land with native plant communities to cropland would reduce nesting and foraging habitat for birds such as pheasant, wild turkeys, sharp-tailed grouse, sage grouse, and meadowlark. Some species would use agricultural crops as an additional source of food. Both sharp-tailed grouse and sage grouse eat alfalfa, and sharp-tailed grouse favor small grains. Field surveys have not been conducted to identify grouse courtship grounds (leks) and nesting areas on or near proposed projects. Impacts to sharptails and sage grouse also could result if agricultural development affects their breeding and courtship display areas. These areas could be rendered inactive or partially inactive if they are greatly altered or affected by increased human or livestock activity during the critical spring courtship and breeding season.

Conversion of native rangeland to irrigated cropland on deer winter range could reduce available forage. On winter range with native plant communities, deer browse on shrubs and dried forbs that remain palatable through the winter. Conversion of native shrubland to grow hay or other crops could reduce this winter forage, particularly if crops are harvested late in the season. Losses in native vegetation could stress wildlife during the winter and increase depredation on crops and hay. Acreages of native plant communities that would be converted for proposed irrigation projects are shown in Tables 6-11 through 6-15.

Increased acreage of agricultural crops would attract big game animals, particularly during the winter and spring. Depredation by game animals on crops is sometimes a landowner complaint. Deer feed on hay stored for livestock and graze on winter wheat and alfalfa when it greens up in the spring. Pronghorn also are attracted to wheat, alfalfa, and other crops. Wildlife damage to crops often requires measures to frighten animals away from problem areas, and if these measures are not sufficient, special hunting seasons may be necessary to kill problem animals.

Birds of prey (raptors) could be affected by development of irrigation projects through disturbance during the nesting and brood rearing period (May through August). Species nesting on or near the ground, such as the northern harrier, ferruginous hawk, and burrowing owl, could be displaced when rangeland is converted. Tree- or cliff-nesting raptors, such as red-tailed hawk, Cooper's hawk, prairie falcon, Swainson's hawk, and golden eagle, also could be displaced from nest sites if agricultural activities such as movement of irrigation structures, plowing, and cultivating take place close to nests during the nesting and brood-rearing periods. Raptors could be electrocuted if they land on electric lines and poles that supply power to irrigation projects, unless poles and lines are constructed to prevent such fatalities. No comprehensive field surveys have been conducted to determine raptor use near proposed projects.

Streamflow reductions due to increased irrigation could increase waterfowl deaths by predation. Geese and ducks nesting on islands would be more vulnerable if instream flows decrease during the nesting or brood rearing period (March and April for geese and April, May, and June for ducks). Both geese and ducks would be less vulnerable to nest predation after hatching. When new powerlines are constructed in areas used by waterfowl, mortalities also could increase as a result of collisions with ground wires and small-diameter electrical conductors.

Impacts to wildlife can result if very low streamflows or periodic cessation of flow reduce food availability and render aquatic wildlife more susceptible to predation. Mink and raccoon rely on fish, mollusks, amphibians, crayfish, and other aquatic invertebrates for food. Very low flows or periodic drying up of streams could reduce populations of aquatic organisms that are food for mink and raccoon.

Beaver and muskrat live in lodges or in burrows in banks with water submerging the entrance. Low streamflows increase the potential for burrows to be entered by predators. Reduced water depths in streams also expose muskrat and beaver to increased predation while they are foraging in the stream.

Impacts of municipal water withdrawals on wildlife would be negligible.

### LOWER MISSOURI RIVER SUBBASIN

Development of irrigation projects under the Consumptive Use Alternative would result in removal of large areas of riparian vegetation along the lower Missouri River bottomlands. A combined total of about 4,100 acres of woodland (mostly cottonwood) and shrub/scrub habitat and about 4,800 acres of prairie and mixed prairie habitat would be converted to cultivated fields. Under the Combination Alternative, about 3,700 acres of woodland and scrub/shrub habitat and 4,600 acres of mixed prairie and prairie habitat would be lost. The Instream Alternative would entail loss of only about 275 acres of woodland and scrub/shrub habitat and 1,500 acres of mixed prairie and prairie habitat. Additional riparian habitat would be lost to pipelines and canals under all alternatives; losses would be greatest under the Consumptive Use Alternative and least under the Instream Alternative. The woodland, mixed prairie, and scrub/shrub habitats are important because they are mostly limited to the area adjacent to the Missouri River and a few small drainages. They provide cover for deer and important habitat for furbearers, pheasants, wild turkeys, and a variety of nongame songbirds and raptors.

Outside the Missouri River valley, about 620 acres of rangeland habitat would be lost under the Consumptive Use Alternative, 200 acres under the Combination Alternative, and roughly 160 acres under the Instream Alternative.

Construction of the diversion pumps could disturb nesting least terns and piping plovers and cause them to abandon their nests. Both least terns and piping plovers nest on sand and gravel bars and islands along the Missouri River. Table 6-25 indicates the projects that are within a mile of sightings of these species. The nesting locations can vary from year to year, and given the term of these reservations, it is likely that additional nesting sites would be found. Lowering water levels may increase predators' access to a few islands with shallow channels. Channel movement could easily change the location and number of potentially affected islands and nesting areas between now and the time the reservations for irrigation are put to use.

**Table 6-25. Projects within 1 mile of known sightings of least terns or piping plovers**

| | Alternative | | |
|---|---|---|---|
| Project | Consumptive Use | Instream | Combination |
| RI-08 | X | — | X |
| MC-11 | X | — | X |
| CBI-3 | X | — | X |
| CBI-19 | X | — | X |

— indicates a project is not included in this alternative

Depredation of haystacks by deer is likely to increase on projects close to woodland and scrub/shrub habitat (see Appendix F). Such depredation would be greatest under the Consumptive Use Alternative and least under the Instream Alternative.

Wetland habitats important to a variety of wildlife species would be cultivated. Comprehensive wetland surveys have not been completed for projects above Brockton. Based on wetland studies conducted by USFWS below Brockton, small wetlands are likely to be included in many of the projects. Wetlands may be filled to facilitate movement of center pivots and wheel lines. Sufficient project design detail is not available to identify precisely where this might occur. More wetland areas are likely to be affected under the Consumptive Use Alternative than by the Combination or Instream alternatives (see Mitigation for further discussion).

Proposed irrigation projects within the Poplar River drainage would cultivate about 345 acres of rangeland and 335 acres of land in the CRP program under the Consumptive Use Alternative, 150 acres of rangeland and 335 acres of land in the CRP program under the Combination Alternative, and 61 acres of rangeland under the Instream Alternative. The greatest potential impact would result from lowering of the water table and altering riparian vegetation and habitat.

### MILK RIVER SUBBASIN

In the Milk River subbasin, about 1,800 acres of rangeland habitat would be inundated by a dam under the Consumptive Use Alternative, 50 acres under the Combination Alternative, and none under the Instream Alternative. A few areas of predominantly cottonwood forest would be affected under any of the alternatives. Of the projects proposed in the Milk River subbasin, the dam proposed for project BL-181 would have the greatest potential to affect wildlife habitat. It would flood about 1,800 acres of rangeland. Most large pools in Battle Creek support nesting ducks. These areas would be flooded at the reservoir site. This reservoir is expected to be drawn down yearly. Filling the reservoir during the spring could limit its use for waterfowl nesting because of flooding of nest sites. In 1 to 2 years in 10, the reservoir levels may be stable enough to allow successful nesting. Several roosts used by raptors on the cliff near the dam may be flooded.

### LITTLE MISSOURI RIVER SUBBASIN

Under the Consumptive Use Alternative, about 2,700 acres of rangeland in the Little Missouri River subbasin would be cultivated and would lose value as wildlife habitat. Most of the irrigation projects are relatively small (the largest is 272 acres) and are scattered throughout the subbasin rather than concentrated in one area. About 890 acres of rangeland would be converted under the Combination Alternative, and about 442 moist prairie acres would be affected under the Instream Alternative.

A few projects (Table 6-26) would eliminate some bushy habitat adjacent to creeks. Areas of trees and brush next to stream channels are limited in these areas and could be locally important to wildlife such as upland gamebirds and deer.

Depletions upstream from Lamesteer National Wildlife Refuge would slightly decrease the frequency with which the reservoir fills and could reduce waterfowl production there. Table 6-27 identifies the projects that are located upstream from the reservoir.

Projects would reduce flows slightly during the spring but would not eliminate waterfowl nesting habitat on Beaver, Little Beaver, or Boxelder creeks, or on the lower end of the Little Missouri River under any of the alternatives. Waterfowl might use water-spreading projects that would retain water through the spring.

**Table 6-26. Projects in the Little Missouri River subbasin that contain woody draw vegetation adjacent to streams**

| | | Alternative | |
|---|---|---|---|
| | Consumptive Use | Instream | Combination Alternative |
| LB-11 | yes | — | — |
| LB-151 | yes | — | yes |
| WI-43 | yes | — | yes |
| WI-92 | yes | — | — |

— indicates project is not included in this alternative

**Table 6-27. Projects that would cause Lamesteer Reservoir to fill less frequently**

| | Consumptive Use Alternative | Instream Alternative | Combination Alternative |
|---|---|---|---|
| WI-61 | yes | — | — |
| WI-201 | yes | — | yes |
| WI-202 | yes | — | yes |
| WI-221 | yes | — | — |

— indicates project is not included in this alternative

Diversion dikes would fill some wetland habitat. Complete wetland surveys have not been conducted in this subbasin, and it is not known how many projects would fill wetlands. Permits would be required before wetlands could be filled.

### SHERIDAN COUNTY GROUNDWATER AREA

Full development of irrigation projects in the Sheridan County Groundwater Area would result in a general drawdown of the aquifer and a substantial decrease in the amount of wetland habitat available to wildlife. Waterfowl production at Medicine Lake and other areas managed for waterfowl production by USFWS could decrease. In some cases, water levels would drop in lakes and ponds surrounding islands used by waterfowl for nesting. During dry periods, nesting success could decrease because the water would not be deep enough or wide enough to prevent skunks and other predators from reaching islands used for nesting. Prolonged drawdown might allow vegetation to encroach and decrease the amount of shoreline habitat available to piping plovers for nesting.

Wetland habitat may be lost if fill is placed in these areas to facilitate movement of center pivots and wheel lines. Not enough project design detail is available to identify precisely where wetlands would be filled.

At least 16,000 acres of the Sheridan County projects include rangeland, pasture, or areas enrolled in the Conservation Reserve Program or other federal programs that provide cover for upland game birds. Cultivation of these areas would eliminate a substantial amount of wildlife habitat.

The corners of many fields that are now cultivated may not be cultivated in the future because proposed center pivot irrigation systems would not reach them. If native vegetation were allowed to recolonize these unused areas, small patches of upland gamebird habitat could develop at field corners but no more than about 500 acres would be created in the Sheridan County project area.

Under the Partial Granting Alternative, impacts would be considerably less than under the Grant All Alternative. No more than 2,493 acres of upland gamebird habitat would be cultivated. Drawdowns for individual projects might adversely affect a few wetlands, but it is not possible to say where these projects and resulting drawdowns might be located. Assuming that no permits for new developments would be issued after reservations are granted, drawdowns probably would affect a substantially smaller acreage than would be affected under the Grant All Alternative.

The Coordinated Groundwater Development Alternative would reduce the likelihood of substantial adverse effects to wetlands that provide wildlife habitat if the project selection process would screen out these projects, which would cause adverse effects. No more than 5,585 acres of upland gamebird habitat would be cultivated.

## HISTORICAL, ARCHAEOLOGICAL, AND PALEONTOLOGICAL RESOURCES

The most likely impacts to historical, archaeological, or paleontological resources would be damage to the sites through indirect or direct disturbance when irrigation or municipal projects are developed. The potential for this loss is greatest on undisturbed land near rivers and streams. Impacts would be considered significant when the damaged sites have the potential to provide further understanding of the past or where a site would be disturbed, destroyed, or altered to the point that it would no longer be eligible for listing on the National Register of Historic Places. Some sites in the lower Missouri River basin may have religious or other cultural value to members of Montana's Indian tribes. The significance of any sites found during project development could not be fully known without additional study.

Direct disturbance could occur through cultivation or irrigation and during construction of wells, electric lines, pipelines, and diversion structures. Indirect disturbance might occur through increased wind or water erosion resulting from cultivation or irrigation. Other indirect effects such as vandalism or unauthorized collection of artifacts are less likely because most projects would be on private land and access would be restricted.

Other indirect effects to historical, archaeological, and paleontological resources could result from fluctuating water levels in Fort Peck. Lowering of water levels in the lake may expose sites to erosion from wave action along the shoreline. While the proposed reservations might affect lake levels slightly, the impacts to shoreline sites are influenced at present by yearly or seasonal operation and changes in water levels at Fort Peck Reservoir. The reservations would contribute slightly to the changing levels and long-term degradation of shoreline sites.

There is some potential for new site discovery during project development, particularly for projects on undisturbed rangeland or pasture. The potential for impacts could be reduced by having a qualified archaeologist or historian collect and record important information or advise on the location of some irrigation equipment, pipelines, or electric lines prior to project development to avoid disturbance at sites determined to be sensitive.

Under the Montana Antiquities Act, the Department of State Lands would be required to evaluate sites on state land and devise methods to retrieve or protect the information. Under the National Historic Preservation Act and the Archaeological and Historic Preservation Act, the Bureau of Land Management (BLM) or other federal land managing agencies would evaluate sites on federal land or land held in federal trust. Federal review would devise methods to retrieve or protect the information contained at discovered sites. Sites on private land would not be evaluated unless the landowners have it done, or unless the Board conditions the reservation to require evaluation prior to development.

Adverse effects on paleontological resources would result if fossils of scientific importance or information about the past associated with them were lost or destroyed. Most of the areas affected by the proposed projects have not been inventoried for paleontological resources. Based on knowledge of past site discovery, DNRC believes that most of the significant fossil discovery in the basin is away from the proposed projects. Still, project development could lead to discovery of new fossil sites, particularly at outcrops of geologic formations known to produce fossils. Discovery of new sites that contribute knowledge of vertebrate species and plant or other life forms would be a beneficial effect if the information contained at such sites is recovered.

## IMPACTS OF THE CONSUMPTIVE USE, INSTREAM, AND COMBINATION ALTERNATIVES

### LOWER MISSOURI RIVER SUBBASIN

**Lower Missouri River:** Table 6-28 lists the reservation projects potentially affecting known historical or archaeological sites. The Consumptive Use Alternative would affect all sites listed in the table; the Combination Alternative would not include projects RI-07, CBI-12, CBI-13, and CBI-18. The Instream Alternative would avoid all sites except those affected by project CBI-17 and MC-03. As noted in the table, many of the known sites are located outside land proposed for irrigation, and impacts would be indirect, such as through vandalism. For other sites, proper placement of irrigation equipment, pipelines, and electric lines, and changes in field boundaries probably could reduce or avoid disturbance to these sites. Landscapes along the Missouri River are likely to contain additional historical and archaeological information. Site types that could be discovered include campsites, burials, tipi rings, and sites associated with more recent settlement of the area.

The probability for new site discovery would be greatest in undisturbed areas of rangeland, particularly benchlands and terraces above the river. Other areas with potential for site discovery include areas of cottonwoods along the river. Impacts to sites discovered during final project design and construction could be kept low if important sites were avoided if possible or, if disturbance was necessary, information contained in sites was collected during project implementation.

Exposures of the Hell Creek geological formation may occur on the north and south sides of the Missouri River between Wolf Point and Poplar, increasing the potential for discovery of vertebrate fossils with scientific value. Such discovery would be a beneficial effect if the information discovered is properly evaluated and recorded.

**Table 6-28. Historical and archaeological sites along the lower Missouri River**

| Project No. | Site No. | Site Type | Location |
|---|---|---|---|
| VA-02 | 24VL0721 | lithic materials[a]; campsite | crossed by proposed pipe and pivot |
| MC-03 | 24MC0071 | buffalo pound, hearth, lithic material | outside of proposed project |
| RI-01 | 24RL0084 | tipi rings, rock alignment, cairn | overlooks proposed irrigation |
| RI-07 | 24RL0189 | historical Rud homestead | within proposed pivot |
| RI-14 | 24RL0507 | lithic materials, campsite hearths | overlooks proposed pivots |
| CBI-12 | 24RV0201 | historical white site | along pipeline |
| CBI-13 | 24RV0415 | Miller homestead | within pivot |
|  | 24RV0414 | Mitchell homestead | within pivot |
|  | 24RV0419 | buried bone bed | within proposed wheel line |
| CBI-16 | 24RV0119 | historical homestead, outbuildings | borders pivot |
|  | 24RV0120 | historical homestead, outbuildings | borders wheel line |
| CBI-17 | 24RV0033 | surface stone quarry | overlooks proposed pivots |
| CBI-18 | 24RV0445 | Harder homestead remnants | borders proposed pivot |
|  | 24RV0133 | segment Great Northern Railroad bed | borders proposed pivot and wheel line |
| CBI-21 | 24RL0086 | Snowden/Nehi railroad bridge | borders proposed pivot and wheel line |
| DA-21 | 24DN0073 | historical wooden bridge | near proposed field |

[a] Lithic materials may include rock chips produced during tool making or finished tools, such as arrowheads, spear points, or scrapers.

SOURCE: Montana Historical Society 1990 - 1993.

**Poplar River Drainage:** Impacts to known historical sites in this drainage would be the same under the Consumptive Use, Instream, or Combination alternatives. Project DA-21 would be developed near site 24DN0073, a historical wooden bridge, but would have no foreseeable effect on it.

Projects in this drainage would be developed on land with moderate to high potential for new archeological site discovery. This potential is greatest for sites that would be developed on undisturbed dry or riparian rangeland (see Appendix G).

Outcrops of the Hell Creek Formation occur across areas along the West Fork and lower Poplar River. Most of the projects proposed in this drainage are located north of these locations. The exceptions are DA-31 and DA-31A, which may have some potential for vertebrate fossil discovery, depending on local geologic deposition. This potential is reduced by the effects of past glaciation, which would have eliminated most features at the surface, particularly in alluvial areas along the West Fork where the proposed irrigation projects are located.

### MILK RIVER SUBBASIN

Two known sites within this subbasin might be affected by proposed reservations under the Consumptive Use Alternative. Project BL-131 would require construction of a small dam across a tributary to Black Coulee where a tipi ring site was discovered during DNRC fieldwork. Depending on final placement of the dam and the area disturbed during construction, this site might be disturbed. Formal evaluation at this site would be necessary to determine whether important information is contained there. Project VA-71 would irrigate land adjacent to the historical Vandalia canal system. Proper placement of the pivot systems and related equipment would avoid disturbance of this canal. The project is included in the Consumptive Use and Combination alternatives.

No geologic formation with potential paleontological significance would be affected by proposed reservations in the Milk River subbasin.

### LITTLE MISSOURI RIVER SUBBASIN

**Little Missouri River Drainage:** No historical or archaeological sites were found in this drainage during file search efforts by DNRC. Except for project CT-012, areas to be irrigated in this drainage are rangeland with moderate potential for new site discovery. The potential for discovery of new vertebrate fossil sites is low.

**Boxelder Creek:** No historical or archaeological sites were found in this drainage during file searches by DNRC. Except for projects CT-121, CT-320, and CT-380 within the Consumptive Use Alternative, and projects CT-122 and CT-221 under either the Consumptive Use or Combination alternatives, proposed irrigation projects would be in rangeland. Undisturbed landscapes along Boxelder Creek have moderate potential for new site discovery.

Projects CT-121, CT-122, and CT-370 are within the Consumptive Use Alternative, and CT-221 is located under either the Consumptive Use or Combination alternatives near outcrops of the Hell Creek geologic formation. The potential for intact vertebrate fossil discovery is limited because the formation is buried by alluvium soils along Boxelder Creek where most of these projects would be developed.

**Little Beaver Creek:** Under the Consumptive Use Alternative, project CT-294 would have no effect on site 24CT0283 since it is located 1/4 mile from the site. Proper placement of irrigation equipment and electric lines could avoid impacts at this site.

As noted in Appendix G, rangeland would be converted under all alternatives, with the Consumptive Use and Combination being nearly identical in the amount of land disturbed. This drainage has moderate potential for new site discovery because of the landscapes affected by the proposed reservations.

Outcrops of the Hell Creek geologic formation are found at the surface in areas near projects LB-061, LB-063, LB-141, LB-181, and LB-182 developed under either the Consumptive Use or Combination alternatives. Still, this project land is generally away from rock outcrops that could produce intact vertebrate fossils.

**Beaver Creek Drainage:** Under the Consumptive Use Alternative, projects WI-121 and LB-161 would not directly affect known archaeological sites, although known sites are located nearby. About half of the projects under the Consumptive Use Alternative and most of those under the Combination Alternative would develop projects on rangeland. These landscapes have a moderate potential for new site discovery.

There are no outcrops of significant vertebrate fossil-bearing geologic formations in areas affected by the proposed reservation projects.

### SHERIDAN COUNTY GROUNDWATER AREA

Table 6-29 lists the projects with potential to affect known sites. Any impact to these sites would be indirect, except for project 90.2, which would irrigate a site within an existing plowed field. Proper placement of irrigation equipment would avoid encroachment on sites near proposed projects. The Partial Granting Alternative would avoid impacts to sites from projects 11.1, 17.1, 73.3, 90.2, 94.3, 105.2, 105.4, 130.2, and 135.6.

Most of the land proposed for irrigation under the Sheridan County proposal has already been cultivated as dryland grain or hay. New disturbance would occur along tributary streams where there is moderate potential for new site discovery. New disturbance in such areas under the district's proposal totals 821 acres. Potential impacts would be less under the Partial Granting and Coordinated Groundwater Development alternatives.

**Table 6-29. Historical and archaeological sites potentially affected by reservations in theSheridan County Groundwater Area**

| Project No. | Site No. | Site Type | Location |
|---|---|---|---|
| 11.1 | 24SH0794 | historical Bedford house | borders proposed wheel line |
| 17.1 | 24SH0594 | lithic materials[a] in plowed field | near proposed wheel line, plowed field |
| 21.3 | 24SH0119 | historical wooden bridge | near proposed pivots |
| 64.2 | 24SH0686 | tipi rings, rock cairn, lithic materials | borders field |
| 73.3 | 24SH0572 | lithic materials, occupation site | near proposed wheel line, plowed field |
| 90.2 | 24SH0590 | lithic materials | within plowed field to be irrigated |
| 94.3 | 24SH0160 | historical farmstead, outbuildings | |
| 157.1, 90.7 | 24SH0718 | historical Syverud homestead | overlooks proposed pivot |
| 130.2 | 24SH0042 | Meyer coal mine | outside of project, reclaimed by DSL |
| 133.3, 135.6 | 24SH0043 | Anderson/Lagerquist coal mines | 5 1/4 miles south of projects, reclaimed by DSL |
| 151.1 | 24SH0161 | historical farmstead, outbuilding | nearby pivot |
| 176.1 | 24SH0707 | Madsen homestead | borders proposed pivot |

[a] Lithic materials may include rock chips produced during tool making or finished tools, such as arrowheads, spear points, or scrapers.
SOURCE: Montana Historical Society 1990 - 1993

## RECREATION

The quality of many water-based recreation activities can be directly affected by instream flows. The streamflow qualities that affect these activities include boatability—the ease with which boats can move up or down a river without hitting obstacles; the speed of streamflow, which determines how fast boats travel down a segment of river; and fishability—stream conditions that contribute to a good fishing experience (Whittaker et al. 1993).

Reservations for consumptive use could adversely affect water-based activities by lowering flows and decreasing boatability, fishability, and rate of travel. For most streams, ease of boating decreases when flows are reduced and it becomes increasingly necessary to drag boats across shallow reaches. Decreased flows also can affect a stream's fishability by altering pools and riffles and by decreasing the amount of fishable water. Fluctuating flows may affect water turbidity and ease of wading through a stream or river. Lastly, decreased flows can increase travel time for boats, especially for multi-day trips. Increased travel time may decrease time spent on shore or make paddling or rowing necessary in nonmotorized craft. Flow-enhanced recreation activities such as wildlife viewing, riverside camping, and hunting can be indirectly affected by low flows that result in stagnant pools and exposed mudflats.

Angler participation in fishing can be affected by several factors. Numerous studies indicate that fishing can provide psychological and social benefits besides the opportunity to catch fish (Driver and Knopf 1976; Driver and Cooksey 1977; Moeller and Engleken 1972). Convenient access can affect participation in recreation. In Hagmann's recreation use study of the upper Clark Fork drainage (1979), fishing and recreating close to home were two important reasons Montana residents gave for visiting streams in this drainage. Allen's study (1988) of 19 Montana rivers indicated that the desire to fish close to home was important in choosing a fishing location. Improving recreational access and facilities is recognized as a priority need for both Fort Peck Reservoir and the Missouri River from Fort Peck Dam to the state line (Governor's Roundtable on Fort Peck Lake and the Missouri River 1992).

Lastly, anglers want to catch fish. Fishing pressure tends to be higher on streams with good water quality and abundant fish populations. Angler use can be indirectly affected by the adequacy of aquatic habitat and streamflows, which can influence fish abundance.

If consumptive use reservations are granted, flows on certain streams will decline incrementally over the reservation development period as individual projects are constructed and more reserved water is used. The severity of effects would vary with flow rates and with the amount, timing, and location of diversions and return flows. Effects of additional depletions would be most severe on reaches of rivers and streams that already have low flows.

Instream flow reservations would help protect existing recreation opportunities on streams but might not fully preserve them. Even without additional withdrawals, very low summer flows and dry reaches on some streams and rivers would continue to occur in dry years.

Construction of new or upgraded diversion structures, powerlines, pipelines, or canals for some irrigation projects might cause short-term effects such as noise and dust. Pipeline construction across steep terrain or erodible soils near rivers and streams could increase water turbidity, which might detract from the recreation setting. Pipeline trenching adjacent to recreation sites could create a short-term nuisance for some recreationists. The magnitude of these short-term construction impacts could be determined after project designs are complete and mitigation measures identified. Checklists available from DNRC for individual projects indicate where short-term construction impacts could occur.

For larger projects such as the Battle Creek Dam north of Chinook or irrigation project CBI-13 covering more than 9,000 acres between Culbertson and Bainville, construction crews could cause short-term impacts when they use recreation areas for temporary housing locations. These impacts would vary with: size of the construction crew, whether crew members are local or nonlocal, timing of construction, and number of recreation sites in the surrounding area. Impacts could include displacement of recreationists who use these sites. Consultation between project developers and the appropriate federal, state, tribal, or local recreation managers would help mitigate this impact. Enforcement of current stay limits at recreation sites also would help avoid such impacts.

Municipal water reservations from surface water or groundwater sources would have a negligible effect on instream flows and water-based recreation. Similarly, instream reservations would not reduce flows below present levels and would help maintain existing opportunities for recreation.

## IMPACTS OF THE CONSUMPTIVE USE, INSTREAM, AND COMBINATION ALTERNATIVES

### LOWER MISSOURI RIVER SUBBASIN

**Missouri River:** The small flow reductions that would occur in the Missouri River from Fort Peck Dam to the Montana/North Dakota state line under the Consumptive Use, Instream, and Combination alternatives would have very minor effects on existing recreation opportunities and settings. Average flow decreases of several hundred cubic feet per second, ranging from 2 to 6 percent of average monthly flow across the three alternatives, would not affect current recreation activities.

Under the Consumptive Use and Combination alternatives, removal of riparian cottonwoods for irrigation projects would change riverside aesthetics in some locations, creating more open views and fewer woodlands along the Missouri River. This effect would be more noticeable along the south bank of the river below Culbertson where proposed projects would remove approximately 2,700 acres of riparian woods. Most of these trees would not be removed under the Instream Alternative.

**Poplar River:** Unless the tribes enforce their instream flow rights granted under the Fort Peck Compact, late summer fishing opportunities on the Poplar River and its forks above the Fort Peck Indian Reservation could be adversely affected. Very low summer flows would occur with greater frequency during dry years under the Consumptive Use Alternative. Effects would occur to a slightly lesser extent under the Combination Alternative and would not occur under the Instream Alternative.

Under the Consumptive Use and Combination alternatives, irrigation withdrawals for requested reservations might affect recreation on Whitetail, Coal, and Butte creeks, and on Olsen Coulee. Recreation on Police Creek could be affected under the Consumptive Use Alternative. Whether these streams are used for recreation is unknown.

**Redwater River:** The municipal reservation requested by the City of Circle is the only consumptive use application in this drainage. Circle would obtain water from deep wells, so this reservation would have negligible recreation effects on the Redwater River.

### MILK RIVER SUBBASIN

Despite flow reductions that would occur due to consumptive use reservations granted under the Consumptive Use, Instream, and Combination alternatives, flow increases in the main-stem Milk River resulting from the Virgelle project during summer months might still result in improved fishing opportunities. The river reach from Dodson to Nashua, however, would continue to experience summer flow levels at or near zero during most years.

Under the Consumptive Use Alternative, summer flow would increase in Battle Creek below the proposed dam during both wet and dry years, which might improve fishing opportunities if habitat is improved and fish populations increase. Flow decreases during March of dry years, however, could dry up any spring fishing opportunities near the mouth. Depending on how the dam is operated, fluctuating streamflows could increase turbidity below the dam and adversely affect fishing. The reservoir may provide limited fishing opportunities, though reservoir drawdowns in most years would severely limit the quality of the fishery. Public access to the reservoir is not planned at this time. The Instream and Combination alternatives would not entail building the dam, and any impacts from the dam would be avoided.

Under the Consumptive Use Alternative, irrigation withdrawals for proposed reservations might affect recreation on Lost Coulee in Liberty County and Black and Link coulees in Blaine County. The extent of recreation use on these intermittent streams is not known.

Instream reservations granted under any of the alternatives on Milk River tributaries would not reduce flows below present levels. Instream reservations would help maintain existing opportunities for recreation, most notably for Beaver Creek, which runs 17 miles through a county park in Hill County, and for both coldwater and warmwater fishing on other tributaries.

### LITTLE MISSOURI RIVER SUBBASIN

Fishing conditions typical of the prairie streams in this subbasin during most summers (low or intermittent flows through long pools) would occur with greater frequency under the Consumptive Use and Combination alternatives on the Little Missouri River and Boxelder and Little Beaver creeks. Under the Instream Alternative, slight flow reductions also would occur on the Little Missouri River and Boxelder and Little Beaver creeks during spring and summer months. Effects of these flow reductions on fishing opportunities should be minimal.

Late summer flows could increase slightly on Beaver Creek under the Consumptive Use and Combination alternatives. The effect of this slight flow increase on fishing opportunities would be minimal.

Under the Consumptive Use and Combination alternatives, irrigation withdrawals might affect recreation on Elkhorn, Cottonwood, and Beaver Dam creeks, and Long Draw in the Little Missouri River drainage; Lamesteer and Spring creeks in the Beaver Creek drainage; Bone Pile, Mud, Duck, Dugout, and HS creeks in the Little Beaver drainage; and Sherril, Hawksnest, East LO, and LO creeks, and Fresh Water Draw in the Boxelder Creek drainage. Most of these streams are intermittent and are unlikely to support a fishery or have recreation use.

### SHERIDAN COUNTY GROUNDWATER AREA

Effects of granting reservations on recreation opportunities on lakes and streams cannot be accurately predicted. Possible effects at Medicine Lake National Wildlife Refuge include drying of some wetlands and potholes and decreasing and changing locations available for wildlife observation and photography. Decreased water levels in Medicine Lake could increase the likelihood of winter kills and decrease fishing opportunities. Decreased water levels in Big Muddy Creek also could further limit fishing opportunities on this stream. These effects probably would vary in intensity with total irrigation withdrawals from all aquifers in the groundwater area and prevailing climatic conditions.

## CHANGES IN RECREATIONAL VALUE DUE TO CHANGES IN STREAMFLOWS

DNRC assessed the change in recreational value by multiplying the recreational value per acre-foot of flow by the estimated changes in average streamflow. Duffield's recreational value per acre-foot of flow for the middle Missouri and Marias/Teton subbasins (Duffield 1990) was used as an approximation of the upper bound of recreational value per acre-foot in the lower Missouri River basin study area. The recreational value per acre-foot is $5.81 during July and August and $1.63 the rest of the year.

DNRC's hydrology model calculated the changes in average streamflows due to both upper Missouri River basin reservations granted by the Board and lower Missouri River basin proposed reservations (Table 6-30). It also calculated the changes in average streamflows due solely to proposed reservations in the lower Missouri River basin (Table 6-31).

Table 6-32 lists the changes in annual value of recreation for the Consumptive Use, Combination, Instream, and No Action alternatives resulting from flow depletions due to upper Missouri River basin reservations and lower Missouri River basin reservations (Table 6-30). It is not known whether the Grant All, Partial Granting, and Coordinated Groundwater Development alternatives for the Sheridan County Groundwater Area would change the annual value of recreation because DNRC could not predict streamflow or water level changes due to proposed water reservations in that area.

Table 6-33 lists the change in annual value of recreation for the Consumptive Use, Combination, Instream, and No Action alternatives resulting from flow depletions due solely to lower Missouri River basin reservations (Table 6-31). Under the Consumptive Use Alternative, the annual value of recreation would be reduced in the lower Missouri River subbasin by about $314,000/yr, by $10,800/yr in the value in the Little Missouri subbasin, and by $12,500/yr in the Milk River subbasin. Under the Combination Alternative, DNRC estimated that the annual value of recreation in the lower Missouri River subbasin would be decreased by $178,000/yr, $7,600/yr in the Little Missouri River subbasin, and $5,400/yr in the Milk River subbasin. Under the Instream Alternative, DNRC estimated that flow depletions would reduce the annual value of recreation in the lower Missouri River subbasin by $11,000/yr, $2,400/yr in the Little Missouri River subbasin, and $3,600/yr in the Milk River subbasin. There would be no change in the annual value of recreation due to reservations under the No Action Alternative, since no lower Missouri River basin reservations are assumed. It is not known whether the Grant All, Partial Granting, and Coordinated Groundwater Development alternatives for the Sheridan County Groundwater Area would change the annual value of recreation because DNRC could not predict streamflow or water level changes due to proposed water reservations in that area.

**Table 6-30. Changes in average flow (acre-feet) due to upper Missouri River basin granted reservations and lower Missouri River basin proposed reservations**

| ALTERNATIVES<br>Subbasin | Changes in July/August average flows | Changes in Rest of Year average flows |
|---|---|---|
| CONSUMPTIVE USE | | |
| Milk River | 8,483 (b) | 9,346 (b) |
| Little Missouri | -1,057 | -2,839 |
| Lower Missouri | -82,005 | -71,567 |
| COMBINATION | | |
| Milk | 7,807 (b) | 16,080 (b) |
| Little Missouri | -848 | -1,634 |
| Lower Missouri | -61,412 | -61,829 |
| INSTREAM | | |
| Milk | 8,176 (b) | 15,899 (b) |
| Little Missouri | -375 | -161 |
| Lower Missouri | -34,855 | -53,733 |
| NO ACTION | | |
| Milk | 8,422 (c) | 17,216 (c) |
| Little Missouri | 0 | 0 |
| Lower Missouri | -33,626 (d) | -51,398 (d) |
| GAA, PGA, CGDA (a) | | |
| Sheridan County | unk | unk |

(a) GAA - Grant All Alternative, PGA - Partial Granting Alternative, CGDA - Coordinated Groundwater Development Alternative
(b) Flow increases would occur as a result of the Virgelle diversion and also the Battle Creek Reservior project in the Consumptive Use Alternative.
(c) Flow increases due solely to Virgelle diversion.
(d) Flow depletions due solely to upper basin projects.

**Table 6-31. Changes in average flow (acre-feet) due to lower Missouri River basin proposed reservations**

| ALTERNATIVES<br>Subbasin | Changes in July/August average flows | Changes in Rest of Year average flows |
|---|---|---|
| CONSUMPTIVE USE | | |
| Milk River | 61 (b) | -7,871 |
| Little Missouri | -1,057 | -2,839 |
| Lower Missouri | -48,379 | -20,169 |
| COMBINATION | | |
| Milk | -615 | -1,137 |
| Little Missouri | -848 | -1,634 |
| Lower Missouri | -27,786 | -10,431 |
| INSTREAM | | |
| Milk | -246 | -1,318 |
| Little Missouri | -375 | -161 |
| Lower Missouri | -1,229 | -2,335 |
| NO ACTION | | |
| Milk | 0 | 0 |
| Little Missouri | 0 | 0 |
| Lower Missouri | 0 | 0 |
| GAA, PGA, CGDA (a) | | |
| Sheridan County | unk | unk |

(a) GAA - Grant All Alternative, PGA - Partial Granting Alternative, CGDA - Coordinated Groundwater Development Alternative
(b) Flow increases would occur as a result of the Battle Creek Reservior project.

**Table 6-32. Changes in annual value of recreation due to reservations granted in the upper Missouri River basin and proposed reservations in the lower Missouri River basin**

| ALTERNATIVES Subbasin | Changes in July/August recreational values | Changes in Rest of Year recreational values | Changes in Total recreational values |
|---|---|---|---|
| CONSUMPTIVE USE | | | |
| Milk | $49,288 | $15,234 | $64,522 |
| Little Missouri | $-6,143 | $-4,628 | $-10,771 |
| Lower Missouri | $-476,449 | $-116,653 | $-593,102 |
| Total | | | $-539,352 |
| COMBINATION | | | |
| Milk | $45,359 | $26,210 | $71,569 |
| Little Missouri | $-4,929 | $-2,663 | $-7,592 |
| Lower Missouri | $-356,801 | $-100,781 | $-457,582 |
| Total | | | $-393,605 |
| INSTREAM | | | |
| Milk | $47,502 | $25,915 | $73,417 |
| Little Missouri | $-2,179 | $-262 | $-2,441 |
| Lower Missouri | $-202,509 | $-87,585 | $-290,094 |
| Total | | | $-219,118 |
| NO ACTION | | | |
| Milk | $48,931 | $28,063 | $76,993 |
| Little Missouri | $0 | $0 | $0 |
| Lower Missouri | $-195,365 | $-83,779 | $-279,144 |
| Total | | | $-202,151 |
| GAA, PGA, CGDA (a) | | | |
| Sheridan County | unk | unk | unk |

(a) GAA - Grant All Alternative, PGA - Partial Granting Alternative, CGDA - Coordinated Groundwater Development Alternative

**Table 6-33. Changes in annual value of recreation due to proposed reservations in the lower Missouri River basin**

| ALTERNATIVES Subbasin | Changes in July/August recreational values | Changes in Rest of Year recreational values | Changes in Total recreational values |
|---|---|---|---|
| CONSUMPTIVE USE | | | |
| Milk | $357 | $-12,829 | $-12,472 |
| Little Missouri | $-6,143 | $-4,628 | $-10,771 |
| Lower Missouri | $-281,083 | $-32,875 | $-313,958 |
| Total | | | $-337,201 |
| COMBINATION | | | |
| Milk | $-3,572 | $-1,853 | $-5,424 |
| Little Missouri | $-4,929 | $-2,663 | $-7,592 |
| Lower Missouri | $-161,435 | $-17,003 | $-178,438 |
| Total | | | $-191,454 |
| INSTREAM | | | |
| Milk | $-1,429 | $-2,148 | $-3,576 |
| Little Missouri | $-2,179 | $-262 | $-2,441 |
| Lower Missouri | $-7,143 | $-3,807 | $-10,950 |
| Total | | | $-16,968 |
| NO ACTION | | | |
| Milk | $0 | $0 | $0 |
| Little Missouri | $0 | $0 | $0 |
| Lower Missouri | $0 | $0 | $0 |
| Total | | | $0 |
| GAA, PGA, CGDA (a) | | | |
| Sheridan County | unk | unk | unk |

(a) GAA - Grant All Alternative, PGA - Partial Granting Alternative, CGDA - Coordinated Groundwater Development Alternative

# POWER PRODUCTION

## GENERAL IMPACTS AND CONSIDERATIONS

Reservations for instream flows would not have any impact on electric power production, while reservations for proposed consumptive uses could affect electric power production in two ways. First, consumptive uses would reduce power production by decreasing flows through hydroelectric generating facilities. Hydropower is currently one of the cheapest forms of generating electricity. This lost power must be replaced with either conservation or new sources of electricity, generally from higher cost facilities. Second, most of the proposed irrigation and municipal reservations would use electric pumps, which would increase the need for additional power. New power acquisitions would increase the cost of electricity to all consumers. The reason for this is that electricity is generally sold at rates based on the average cost of existing facilities. When expensive new facilities are added into the resource mix of generating facilities, the average cost of power, and hence rates, would go up.

## IMPACTS TO HYDROELECTRIC POWER PRODUCTION

None of the consumptive use reservations in the lower Missouri River basin would affect any hydroelectric generating facilities in Montana. Five hydroelectric dams located on the Missouri River in the Dakotas and Nebraska (Garrison, Oahe, Big Bend, Fort Randall, and Gavins Point) would be affected. A portion of the power produced at downstream facilities is sold by the Western Area Power Administration to consumers in Montana. Except in months so wet that water would flow over dams without generating electricity, streamflow depletions from irrigation or municipal consumptive uses would result in reduced electric generation at all of the downstream dams. DNRC estimates that any depletion of flow in the lower Missouri River basin would result in a loss totaling approximately 516 kWh/af at the five downstream dams.

The cost to society of reduced hydropower generation is the increase in replacement power costs and any incremental increase in environmental degradation. These costs depend largely upon the type of the replacement power sources. At present, it is not possible to identify any particular resource that might be chosen to replace lost hydroelectric power. The cost of replacement power, however, might be comparable to the estimated cost of power from a new coal-fired generating plant, which would be on the order of 5 to 10 cents/kWh. Costs resulting from impacts to environmental quality and human health due to the development of coal-fired power plants are not included in the above levelized costs.

It may be argued that regional utilities have surplus capacity, but over a 70-year planning horizon, surplus capacity tends to be temporary, while the proposed irrigation and municipal water reservations are assumed to be long term. Further, the decade of surplus electric-generating capacity has ended in Montana and the Pacific Northwest, and the power surplus in the Great Plains region is expected to end in the coming decade. Thus, hydropower production losses as a result of increased irrigation and municipal withdrawals would increase the need to find additional power sources. The reduction in hydropower generation under each of the alternatives (Tables 6-34 and 6-35) are estimated using the same streamflow depletions that were used in estimating recreational impacts (Tables 6-30 and 6-31). DNRC's hydrology model did not predict any reduced flows from consumptive use reservations in the Sheridan County Groundwater Area so resulting impacts are unknown.

## GENERAL IMPACT FROM INCREASED PUMPING LOADS

Electricity is almost always sold at prices based on the average cost of generation from existing facilities. The cost of replacement power or power from new facilities is generally higher than that from existing facilities. Consequently, new electricity loads can impose costs, sometimes significant, on all other electricity consumers. The feasibility analysis performed by DNRC and the applicant for proposed irrigation projects assumed an average cost of 4 cents/kWh for electricity to be used in pumping water to the projects. If the cost of replacement power averages 5 cents/kWh, a new irrigation project requiring 100 MWh a year would impose costs on other electric consumers amounting to a total of $1,000 a year. If the cost of replacement power averages 10 cents/kWh, the costs to other users of electricity would amount to $6,000 a year for this hypothetical project. Estimated impacts from increased pumping loads also are presented in Tables 6-34 and 6-35.

Table 6-34. **Cumulative reductions in hydroelectric production, increased power demands, and costs to ratepayers due to reservations granted in the upper Missouri basin and requested reservations in the lower Missouri River basin**

| | Alternative | | | | | | |
|---|---|---|---|---|---|---|---|
| | Consumptive Use | Combination | Instream | No Action | GAA (a) | PGA (a) | CGDA (a) |
| Reduced hydroelectric generation (GWH/yr) at dams in downstream states | 102.0 | 85.6 | 66.7 | 64.6 | unk | unk | unk |
| Cost of reduced hydroelectric generation (millions of dollars per year) (b) | 5.10 to 10.20 | 4.28 to 8.56 | 3.33 to 6.67 | 3.23 to 6.46 | unk | unk | unk |
| Increased electric power use (GWh/yr) by irrigation and municipal projects | 31.1 | 15.0 | 2.9 | 0.0 | 19.0 | 0.8 | 2.2 |
| Cost from increased electric power use (millions of dollars per year) (c) | 0.31 to 1.86 | 0.15 to 0.90 | 0.03 to 0.17 | 0.0 | 0.19 to 1.14 | 0.01 to 0.05 | 0.02 to 0.13 |
| Total costs to ratepayers from reduced hydroelectric generation and increased electric power use (millions of dollars per year) | 5.41 to 12.06 | 4.43 to 9.46 | 3.36 to 6.84 | 3.23 to 6.46 | 0.19 to 1.14 | 0.01 to 0.05 | 0.02 to 0.13 |

(a) GAA - Grant All Alternative, PGA - Partial Granting Alternative, CGDA - Coordinated Groundwater Development Alternative

(b) This range of costs is based on the cost of electricity generated at a new coal fired-power plant. Power from such a plant could cost 5 to 10 cents/kWh.

(c) DNRC assumed an electrical rate of 4 cents/kWh in its analysis of proposed irrigation and municipal projects. Acquiring new electric power could increase costs an additional 1 to 6 cents/kWh.

**Table 6-35. Reductions in hydroelectric production, increased power demands, and costs to ratepayers due to water reservations requested in the lower Missouri basin proposed reservations.**

| | Alternative | | | | | | |
|---|---|---|---|---|---|---|---|
| | Consumptive Use | Combination | Instream | No Action | GAA (a) | PGA (a) | CGDA (a) |
| Reduced hydroelectric generation (GWH/yr) at dams in downstream states | 37.4 | 21.0 | 2.1 | 0.0 | unk | unk | unk |
| Cost of reduced hydroelectric generation (millions of dollars per year) (b) | 1.87 to 3.74 | 1.05 to 2.10 | 0.11 to 0.21 | 0.0 | unk | unk | unk |
| Increased electric power use (GWh/yr) by irrigation and municipal projects | 31.1 | 15.0 | 2.9 | 0.0 | 19.0 | 0.8 | 2.2 |
| Cost from increased electric power use (millions of dollars per year) (c) | 0.31 to 1.86 | 0.15 to 0.90 | 0.03 to 0.17 | 0.0 | 0.19 to 1.14 | 0.01 to 0.05 | 0.02 to 0.13 |
| Total costs to ratepayers from reduced hydroelectric generation and increased electric power use (millions of dollars per year) | 2.18 to 5.60 | 1.20 to 3.00 | 0.13 to 0.38 | 0.0 | 0.19 to 1.14 | 0.01 to 0.05 | 0.02 to 0.13 |

(a) GAA - Grant All Alternative, PGA - Partial Granting Alternative, CGDA - Coordinated Groundwater Development Alternative

(b) This range of costs is based on the cost of electricity generated at a new coal fired-power plant. Power from such a plant could cost 5 to 10 cents/kWh.

(c) DNRC assumed an electrical rate of 4 cents/kWh in its analysis of proposed irrigation and municipal projects. Acquiring new electric power could increase costs an additional 1 to 6 cents/kWh.

## SOCIOECONOMICS

### EMPLOYMENT, INCOME, AGRICULTURAL SALES, AND TAXATION

Development of the irrigation projects included in each alternative would cause farm-related employment to increase by 12 to 100 employees in the lower Missouri River basin (Table 6-36). However, these small potential increases would be offset by the ongoing decline in labor required to work the gradually decreasing amount of irrigated land in the basin. Farm income is projected to increase by $0.2 million to $1.6 million. Total farm employment and income in the lower Missouri River basin would increase by less than 0.5 percent under any of the alternatives.

Cash receipts from the sale of agricultural products are projected to increase by $2.1 million to $17.2 million—0.5 percent to 4.2 percent. The taxable valuation of the basin and tax receipts from increased valuation would both increase by less than 0.5 percent.

### IMPACTS OF THE CONSUMPTIVE USE, INSTREAM, AND COMBINATION ALTERNATIVES

Tables 6-37 through 6-40 describe the effects of the alternatives on total employment, personal income, agricultural sales, agricultural-related taxable valuation, and tax receipts in each of the subbasins. Under the Consumptive Use Alternative, the lower Missouri River subbasin and Sheridan County Groundwater Area could experience the largest increase in agricultural employment—about 38 jobs in the lower Missouri River subbasin and up to 56 in the Sheridan County Groundwater Area. The Little Missouri and Milk River subbasins would experience negligible increase in employment under the Consumptive Use Alternative. Under the Combination Alternative, only the lower Missouri River subbasin would experience any substantial increase in employment (23 jobs). None of the subbasins would realize any large increase in employment under the Instream Alternative.

**Table 6-36. Economic benefits to agriculture under various alternatives - lower Missouri River basin**

| Category | Average 1989-91 | Increase | Percent increase |
|---|---|---|---|
| Consumptive Use Alternative | | | |
| Total employment | 38,918 | 100 | .3% |
| Total farm income | $970,782,000 | $ 1,648,803 | .2% |
| Agriculture sales | $408,780,000 | $17,212,658 | 4.2% |
| Ag taxable valuation | $193,806,000 | $ 570,238 | .3% |
| Tax receipts | $ 52,327,000 | $ 151,257 | .3% |
| Combination Alternative | | | |
| Total employment | 38,918 | 30 | negligible[a] |
| Total farm income | $970,782,000 | $ 872,900 | negligible |
| Agriculture sales | $408,780,000 | $ 5,075,983 | 1.2% |
| Ag taxable valuation | $193,806,000 | $ 343,929 | .2% |
| Tax receipts | $ 52,327,000 | $ 92,208 | .2% |
| Instream Alternative | | | |
| Total employment | 38,918 | 12 | negligible |
| Total farm income | $970,782,000 | $ 199,148 | negligible |
| Agriculture sales | $408,780,000 | $ 2,061,798 | .5% |
| Ag taxable valuation | $193,806,000 | $ 218,473 | .1% |
| Tax receipts | $ 52,327,000 | $ 57,825 | .1% |

[a] negligible amounts are less than 0.1 percent

SOURCE: Economic Consultants Northwest 1993

**Table 6-37. Economic benefits to agriculture under various alternatives - lower Missouri River subbasin**

| Category | 1989-91 | Average Increase | Percent increase |
|---|---|---|---|
| Consumptive Use Alternative | | | |
| Total employment | 17,792 | 38 | .2% |
| Total farm income | $358,673,000 | $ 591,902 | .2% |
| Agriculture sales | $156,052,000 | $7,123,620 | 4.6% |
| Ag taxable valuation | $ 32,239,000 | $ 272,637 | .8% |
| Tax receipts | $ 9,512,000 | $ 72,321 | .8% |
| Combination Alternative | | | |
| Total employment | 17,792 | 23 | .1% |
| Total farm income | $358,673,000 | $ 805,377 | .3% |
| Agriculture sales | $156,052,000 | $4,216,405 | 2.7% |
| Ag taxable valuation | $ 32,239,000 | $ 175,714 | .5% |
| Tax receipts | $ 9,512,000 | $ 47,387 | .5% |
| Instream Alternative | | | |
| Total employment | 17,792 | 4 | negligible[a] |
| Total personal income | $358,673,000 | $ 44,940 | negligible |
| Agriculture sales | $156,052,000 | $ 798,965 | .5% |
| Ag taxable valuation | $ 32,239,000 | $ 34,275 | .1% |
| Tax receipts | $ 9,512,000 | $ 9,105 | negligible |

[a] negligible amounts are less than 0.1 percent
SOURCE: Economic Consultants Northwest 1993

**Table 6-38. Economic benefits to agriculture under various alternatives - Milk River subbasin**

| Category | 1989-91 | Average Increase | Percent increase |
|---|---|---|---|
| Consumptive Use Alternative | | | |
| Total employment | 20,091 | 3 | negligible[a] |
| Total farm income | $572,770,000 | $242,575 | negligible |
| Agriculture sales | $219,244,000 | $175,957 | negligible |
| Ag taxable valuation | $ 40,165,000 | $ 37,747 | negligible |
| Tax receipts | $ 10,713,000 | $ 10,100 | negligible |
| Combination Alternative | | | |
| Total employment | 20,091 | 2 | negligible |
| Total farm income | $572,770,000 | $ 20,657 | negligible |
| Agriculture sales | $219,244,000 | $155,864 | negligible |
| Ag taxable valuation | $ 40,165,000 | $ 5,920 | negligible |
| Tax receipts | $ 10,713,000 | $ 1,851 | negligible |
| Instream Alternative | | | |
| Total employment | 20,091 | <1 | negligible |
| Total farm income | $572,770,000 | $ 1,018 | negligible |
| Agriculture sales | $219,244,000 | $ 26,499 | negligible |
| Ag taxable valuation | $ 40,165,000 | $ 1,006 | negligible |
| Tax receipts | $ 10,713,000 | $ 315 | negligible |

[a] negligible amounts are less than 0.1 percent
SOURCE: Economic Consultants Northwest 1993

**Table 6-39. Economic benefits to agriculture under various alternatives - Little Missouri River subbasin**

| Category | 1989-91 | Average Increase | Percent Increase |
|---|---|---|---|
| Consumptive Use Alternative | | | |
| Total employment | 3,203 | 3 | negligible[a] |
| Total farm income | $89,093,000 | $ 55,393 | negligible |
| Agriculture sales | $47,644,000 | $858,091 | 1.8% |
| Ag taxable valuation | $ 8,678,000 | $ 19,191 | .2% |
| Tax receipts | $ 5,507,000 | $ 5,296 | negligible |
| Combination Alternative | | | |
| Total employment | 3,203 | 2 | negligible |
| Total farm income | $89,093,000 | $ 19,678 | negligible |
| Agriculture sales | $47,644,000 | $176,773 | .4% |
| Ag taxable valuation | $ 8,678,000 | $ 10,118 | .1% |
| Tax receipts | $ 5,507,000 | $ 2,792 | negligible |
| Instream Alternative | | | |
| Total employment | 3,203 | 1 | negligible |
| Total farm income | $89,093,000 | $ 4,452 | negligible |
| Agriculture sales | $47,644,000 | $ 56,658 | .1% |
| Ag taxable valuation | $ 8,678,000 | $ 3,243 | negligible |
| Tax receipts | $ 5,507,000 | $ 895 | negligible |

[a] negligible amounts are less than 0.1 percent
SOURCE: Economic Consultants Northwest 1993.

**Table 6-40. Economic benefits to agriculture under various alternatives - Sheridan County Groundwater Area**

| Category | 1989-91 | Average Increase | Percent increase |
|---|---|---|---|
| Grant All Alternative | | | |
| Total employment | 2,278 | 56 | 2.5% |
| Total farm income | $73,914,000 | $ 758,933 | 1.0% |
| Agriculture sales | $23,989,000 | $9,054,990 | 37.7% |
| Ag taxable valuation | $ 5,605,000 | $ 240,663 | 4.3% |
| Tax receipts | $ 1,479,000 | $ 63,540 | 4.3% |
| Partial Granting Alternative | | | |
| Total employment | 2,278 | 3 | .1% |
| Total personal income | $73,914,000 | $ 27,188 | negligible |
| Agriculture sales | $23,989,000 | $ 526,941 | 2.2% |
| Ag taxable valuation | $ 5,605,000 | $ 152,177 | 2.7% |
| Tax receipts | $ 1,479,000 | $ 40,178 | 2.7% |
| Coordinated Groundwater Development Alternative | | | |
| Total employment | 2,278 | 7 | .3% |
| Total farm income | $73,914,000 | $ 148,738 | .2% |
| Agriculture sales | $23,989,000 | $1,179,676 | 4.9% |
| Ag taxable valuation | $ 5,605,000 | $ 179,949 | 3.2% |
| Tax receipts | $ 1,479,000 | $ 47,510 | 3.2% |

[a] negligible amounts are less than 0.1 percent
SOURCE: Economic Consultants Northwest 1993

Under the Consumptive Use Alternative, personal income in the lower Missouri River subbasin would increase by $0.6 million. Neither the Little Missouri River nor the Milk River subbasins would realize a noticeable increase in income under the Consumptive Use Alternative.

Under the Consumptive Use Alternative, the lower Missouri River subbasin would experience the greatest increase in agricultural sales. Sales would increase by $9.1 million (see Table 6-40) and by $7.1 million in the lower Missouri River subbasin (Table 6-37). All the subbasins would experience some increases in agricultural sales under all of the alternatives; however, sales increases in the Little Missouri River and Milk River subbasins would be less than 2 percent under all alternatives.

In all but the Sheridan County Groundwater Area, agricultural-related valuation would increase by less than 1 percent under all alternatives.

In the Sheridan County Groundwater Area under the Grant All Alternative, a maximum of 56 jobs might be created, personal income might grow by $0.8 million, agricultural sales might increase by $9.1 million, and taxable value and tax receipts might increase by 4.3 percent. However, as described under Groundwater earlier in this chapter, the aquifers in this area are not likely to support full development of all projects. Under the Partial Granting and Coordinated Groundwater Development alternatives, increases in employment and personal income would be 0.3 percent or less, while increases in agricultural sales, taxable valuations, and taxes would be less than 5 percent (Table 6-40).

## POPULATION

Population in the lower Missouri River basin has declined from 82,711 in 1970 to 76,865 in 1990, or by approximately 7 percent. All subbasins experienced population loss during this time period with the lower Missouri River and the Milk River subbasins experiencing the greatest decreases (Figure 4-10). Projections for the basin indicate continued decreases in population until the year 2000 when population is expected to begin increasing slightly (NPA 1993). None of the populations in the subbasins in the lower Missouri River basin would be appreciably affected by any of the alternatives.

## POPULATION IMPACTS

Each municipal applicant developed a population projection based on 1989 population information. In most cases, municipal population declines continued through the 1990 census (see Appendix K). Table 6-41 compares the applicant's population projections with those of a national forecasting group.

## SOCIAL EFFECTS

The development of additional irrigation projects and the establishment of some instream flow reservations would not noticeably change the character of

**Table 6-41. Summary of population projections for the lower Missouri River basin municipalities**

| | | Applicant population projection for the year 2035 | | NPADATA, Inc. population projection for the year 2035 | | Level of agreement between these two population projections |
|---|---|---|---|---|---|---|
| City/Applicant | 1990 population | Population | (average annual growth rate) | Population | (average annual growth rate) | |
| Chinook | 1,512 | 2,471 | 1.1% | 1,710 | 0.3% | widely divergent |
| Circle | 805 | 1,176 | 0.8% | 700 | -0.3% | widely divergent |
| Culbertson | 796 | 1,530 | 1.5% | 820 | 0.1% | widely divergent |
| Ekalaka | 439 | 639 | 0.8% | 380 | -0.3% | widely divergent |
| Fort Peck | 325 | 400 | 0.5% | 270 | -0.4% | low agreement |
| Havre | 10,201 | 13,685 | 0.7% | 11,420 | 0.3% | low agreement |
| Hill County Water District | 3,292 | 4,300 | 0.6% | 3,700 | 0.3% | low agreement |
| Harlem | 882 | 1,483 | 1.2% | 1,000 | 0.3% | low agreement |
| Malta | 2,340 | 2,825 | 0.4% | 2,520 | 0.2% | moderate agreement |
| Plentywood | 2,136 | 2,950 | 0.7% | 1,660 | -0.6% | widely divergent |
| Poplar | 881 | 1,678 | 1.4% | 910 | 0.1% | widely divergent |
| Scobey | 1,154 | 1,677 | 0.8% | 780 | -0.9% | widely divergent |
| Wibaux | 628 | 786 | 0.5% | 600 | -0.1% | low agreement |
| Wolf Point | 2,880 | 4,300 | 0.9% | 2,970 | 0.1% | widely divergent |

the lower Missouri River basin communities. Towns such as Havre, Glasgow, and Wolf Point would still serve as local or regional agricultural trade and service centers.

There are some social constraints to the development of large irrigation projects involving multiple landowners. Multiple landowners require assumption of development responsibilities jointly, necessitating substantial coordination and cooperation. Therefore, multi-party irrigation developments may be limited by the difficulty of achieving agreement on land use goals, financial liabilities, and a coordinated development schedule. Projects are often delayed where long-term landowner goals differ or the future price of farm products is uncertain.

Another constraint to project development is nonbenefitting landowners' opposition to installation of project facilities on their property. Major components of some of the larger projects could include pump stations, canals, and electric lines that may be located on or near land owned by other parties. Often, these parties do not stand to profit or otherwise benefit from the proposed facilities and may object to having them on their property.

### COMMUNITY SERVICES

Little additional permanent employment would result from the development of irrigation projects. However, projects that require the construction of storage reservoirs, large pipelines, or extensive canals could require more labor than may be available locally. The in-migration of workers would place additional demand on community schools, medical, water supply, and waste disposal facilities, and law enforcement agencies. Most construction projects would be completed in one field season, and these impacts would be limited to that time period.

## NO ACTION ALTERNATIVE

If the Board does not grant any of the reservation applications, consumptive water users could still apply to appropriate water through the water use permitting process. If no water is available for appropriation, municipalities could still buy or condemn existing water rights. Future water users may be able to purchase water from existing right holders or from the Fort Peck tribes.

It is difficult to predict the amount of new irrigation that would occur without the reservations in the basin through the permitting process. Any amount would depend on economic conditions, the effect of water quality constraints, and the physical and legal availability of water. Declines in existing irrigated acreage due to poor economic climate and changes in land use practices may offset any increase in the amount of acreage developed for new irrigation or consumptively used for other uses. It is difficult to predict the net effect of these changes with accuracy.

If the Board takes no action or denies the proposed reservations, flow patterns in both the Milk and Missouri rivers would still change from those seen today. Flows would decrease somewhat in the lower Missouri River and, if the Virgelle Diversion is constructed, could increase in the Milk River. These flow changes would result from future exercise of reservations for consumptive use granted by the Board during the upper Missouri reservation proceeding and modified by the 1993 Legislature.

If the Board takes no action or denies reservations, permits could still be issued in the Sheridan County Groundwater Area. Since DNRC issues permits on a case-by-case basis, control over groundwater development in the aquifer is limited, unless the area is declared a controlled groundwater area. The aquifer system could be susceptible to over-appropriation, and wetlands and lakes providing waterfowl habitat might not be protected against cumulative impacts of high-yield wells. The magnitude of these effects would depend on the amount of development that occurs and site-specific factors that cannot be known in advance.

Eventually the flows of the Missouri River may be divided among Missouri River basin states. This could be done by Congress, by an agreement or compact between the states, or by the U.S. Supreme Court. In any case, if reservations are not granted for the municipal and irrigation projects, Montana's case for protecting water for these uses would not be as strong. According to Trelease (1982), the reservation process will provide a clear basis for Montana to protect water for future needs. The process provides this by carefully documenting points of diversion and place and type of use, by including only projects that are at least marginally feasible, and by requiring the reservants to be diligent in developing their reservations. These projects also could be protected to some extent by identifying them in a state water planning document or inventorying them as future water development needs.

A benefit of granting reservations and completing the reservation process is that it provides a means for the state to divide water among competing instate users. The No Action Alternative could leave the state undecided as to how water should be allocated in the basin.

If no instream reservations are granted, instream flows in many streams would have no legal protection. In some instances, flows might be appropriated to the point where a stream becomes low or goes dry with resulting detrimental effects to aquatic life, wildlife, and recreation. On streams where low flows are already a problem, the situation could worsen. Instream flows, aquatic habitat, and existing recreation opportunities for several streams on the Fort Peck Indian Reservation—the Middle and West Forks of the Poplar River, Big Muddy Creek, and the Poplar River—may be protected indirectly by the compact with the Fort Peck tribes.

Table 6-42 indicates the flow thought necessary to protect aquatic habitat in the Missouri River from the confluence of the Milk River to the Montana/North Dakota border and compares the percentage of time these flows would be equalled or exceeded under existing conditions to the percentage if the Board takes no action or denies the proposed reservations. If the Board were to take no action or deny reservations in the Milk River subbasin, flows and aquatic habitat would generally improve in the Milk River if BUREC builds and operates the Virgelle Diversion, for which the Board reserved water during the reservation proceedings for the upper Missouri River basin.

Even without the proposed reservations, electricity consumers could be subject to higher rates because of increased pumping loads and flow reductions caused by new consumptive use withdrawals granted in the upper Missouri River reservation proceedings and new development. Water quality could incrementally deteriorate to the detriment of some water uses. The extent to which arsenic would continue to limit new development is unclear.

Reservations are requested for only five new storage projects. If existing trends continue without reservations, few new storage projects will be built over the next 25 years. This is because of the existing environmental, water availability, financial, and economic constraints, and because storage projects have already been constructed at many of the best sites.

If the Board does not grant reservations, the water use permits issued after July 1, 1985, in the lower Missouri and Milk River subbasins, and July 1, 1989, in the Little Missouri River subbasin would not be subordinated to any of the reservations (Appendix A).

Further, under the No Action Alternative, the following reasonably foreseeable events also could result in substantial changes in streamflow and environmental effects.

## OTHER REASONABLY FORESEEABLE EVENTS

MEPA requires an EIS not only to examine the proposed state action, but also to consider the cumulative impacts of past and other reasonably foreseeable, related future actions. DNRC has already analyzed the effects of reservations granted in the upper Missouri River basin as part of its impact analyses for the Combination, Consumptive, Instream, and No Action alternatives earlier in this chapter. In the sections below, DNRC describes actions that may take place outside the reservation proceeding, which could substantially change flows in either the Milk or Missouri rivers. These actions, which would be taken by parties or agencies other than the Board, could result in cumulative effects when combined with the alternatives considered in this EIS. As a result, flow changes and resulting impacts would be in addition to those described under the Consumptive Use, Combination, Instream, and No Action alternatives.

Because of the uncertainty in predicting these future events, DNRC's analysis of these events has been limited. Most of these actions are beyond the scope of this EIS, but the Board may wish to consider them in assigning priority to the proposed reservations.

### FORT PECK DAM OPERATION PLANS

In the impact discussions earlier in this chapter, DNRC assumed that the Army Corps of Engineers would continue to operate Fort Peck Dam as it has in recent years. Corps operation plans for Fort Peck and other main-stem reservoirs farther downstream currently are under review, and a draft EIS concerning this review will soon be published. The outcome of this review could lead to changes in the way reservoirs are operated and affect flows in the Missouri River below Fort Peck and water levels within the reservoir. The Board could not require the Corps to

**Table 6-42. Changes in flow affecting aquatic habitat in the Missouri River near the Montana-North Dakota border under the No Action and Canadian development scenario.**

| Approximate flows(cfs) necessary to maintain aquatic habitat in the Missouri River at the Montana-North Dakota border during certain periods[a] | | | Percent of the time flow is equaled or exceeded under existing conditions | | Percent of the time flow is equaled or exceeded under No Action Altemative[b] | | Percent of the time flow would be equaled or exceeded with full development of reservations and Canadian water[c] | |
|---|---|---|---|---|---|---|---|---|
| Purpose | Period | Flow (cfs) | Period | Percent | Period | Percent | Period | Percent |
| Maintain habitat for sauger spawning and incubation | May 11 - June 30 | 11,500 | May | 21 | May | 19 | May | 16 |
| | | | June | 27 | June | 26 | June | 25 |
| Maintain main channel riffle habitat | July 1 - May 10 | 7,000 | July | 92 | July | 92 | July | 83 |
| | | | August | 72 | August | 72 | August | 70 |
| | | | September | 69 | September | 66 | September | 65 |
| | | | October | 39 | October | 36 | October | 36 |
| | | | November | 45 | November | 42 | November | 42 |
| | | | December | 100 | December | 100 | December | 100 |
| | | | January | 100 | January | 100 | January | 100 |
| | | | February | 100 | February | 100 | February | 100 |
| | | | March | 98 | March | 95 | March | 95 |
| | | | April | 69 | April | 70 | April | 63 |
| | | | May | 65 | May | 64 | May | 58 |

[a] SOURCE DFWP 1991

[b] Includes only flow reductions resulting from exercise of reservations granted in the upper Missouri River water reservation process

[c] Includes flow reductions resulting from exercise of reservations granted in the upper Missouri River water reservation process, reservations included under the Consumptive Use Altemative, and full use of water alloted to Canada in the Milk River subbasin

make changes in operations. These changes and resulting impacts cannot be predicted with any degree of confidence at this time. If timely additional information regarding these changes becomes available, it will be provided to the Board in the final EIS.

## PALLID STURGEON RECOVERY PLAN

USFWS has issued a recovery plan for endangered pallid sturgeon inhabiting the lower Missouri River. This plan calls for a more natural flow pattern in the river. USFWS is consulting with the Corps on possible changes to the Master Manual to bring reservoir operations into compliance with the pallid sturgeon recovery plan. It is not yet known what effect this will have on releases from Fort Peck Reservoir.

## FUTURE DEVELOPMENT BY THE TRIBES OF THE FORT PECK INDIAN RESERVATION

As summarized in the Legal Water Availability section of Chapter Four, the tribes of the Fort Peck Indian Reservation have negotiated a compact with Montana that entitles them to water from the Missouri River, certain of its tributaries, and groundwater beneath the reservation. The tribes are entitled to the lesser of: (1) 1,050,472 af/yr of water; or (2) the quantity of water necessary to supply a consumptive use of 525,236 af/yr. Most of this water would come from the Missouri River, with the largest diversions during the summer.

It is uncertain when, where, and how the tribes would develop this water. A substantial amount of the water may be used to develop irrigation projects in the Missouri River floodplain and adjacent uplands. If water marketing provisions of the compact are approved by the U.S. Congress, compact water could be developed upstream or downstream from the Fort Peck Indian Reservation, or in other states. Because of these uncertainties, the magnitude of cumulative impacts resulting from development of the Fort Peck Compact water is difficult to predict. However, full use of water by the tribes in addition to the new uses described under the Consumptive Use, Combination, and Instream alternatives could have substantial effects on flows in the Missouri River and its tributaries, and on water quality, aquatic life, recreation, vegetation, wetlands, wildlife habitat, and soils.

## CANADIAN DEVELOPMENT SCENARIO

The amount of water available to the Canadians is summarized in the Legal Water Availability section of Chapter Four. If the Board grants all reservations, and if the Canadians develop all water allocated to them through international treaties, and the Virgelle Diversion is not constructed, streamflows would decrease on the main stem of the Milk River (Figure 6-15). During many years, these depletions would result in shortages of irrigation water in the Milk River basin. Water quality would decline in the lower reaches of the Milk River during dry years, and might be marginal for irrigation and unsuited for public drinking water.

Physical water quality may decline further with increases in temperature and turbidity and a reduction in dissolved oxygen that would be harmful to aquatic life. Already marginal aquatic habitat conditions would decline. Cumulative effects on recreation and fishing opportunities in the Milk River from use of water in Canada are uncertain.

Table 6-42 shows how flow would change from Canadian development, reservations granted in the upper Missouri River, and those proposed in the lower Missouri River reservation proceedings could affect aquatic habitat in the lower Missouri River near the Montana/North Dakota border. These estimates assume future operation of Fort Peck Dam would remain the same as in the recent past.

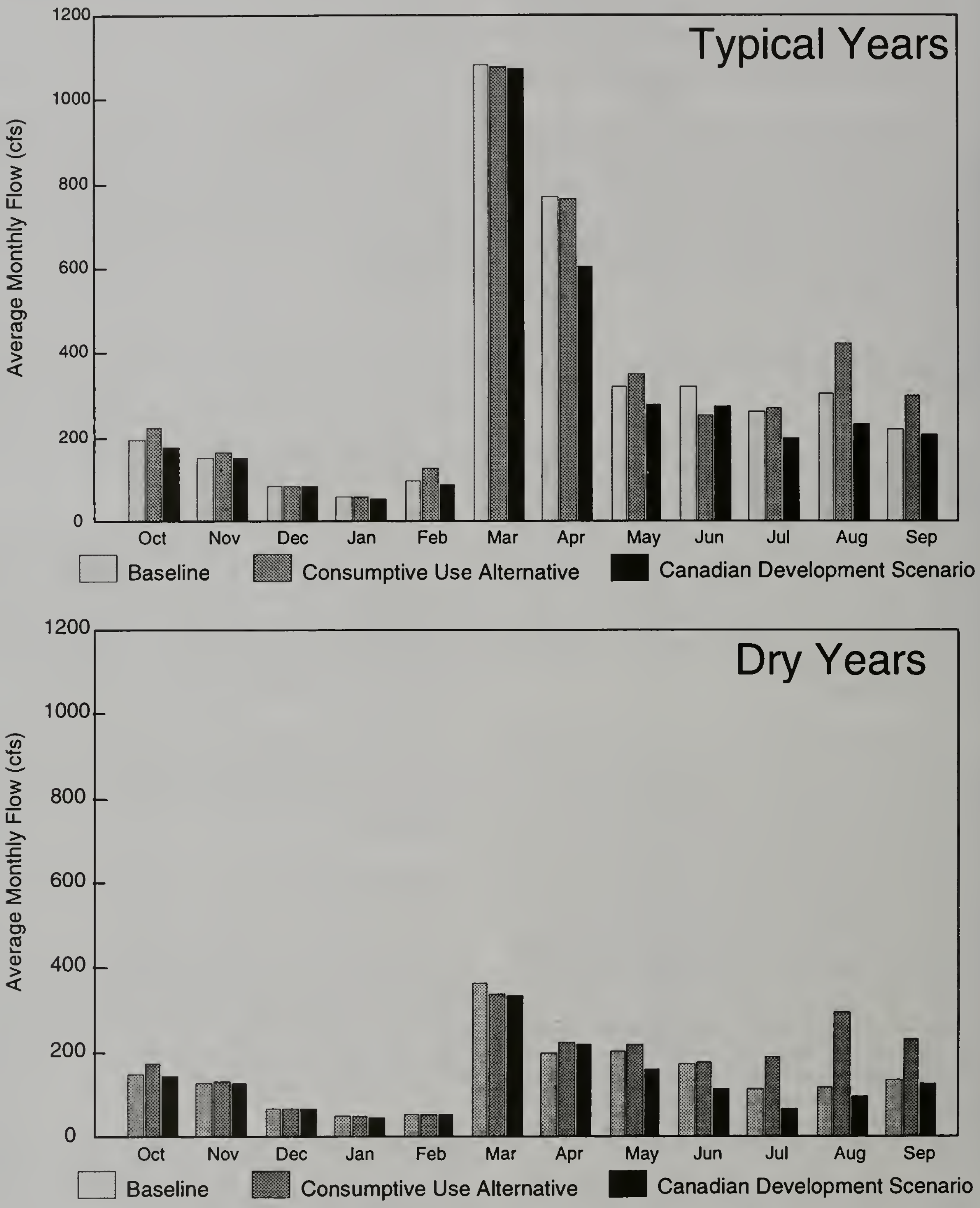
Summer flow reductions in the Missouri River below Wolf Point might alter existing patterns of recreation use and fishing opportunities could decrease. In dry years, boat fishing and floating might become more difficult.

## CANADIAN BATTLE CREEK PROJECT

Saskatchewan is proceeding towards development of a reservoir on Battle Creek just north of the international border. The design of the project is complete, and preparation of the contract drawings awaits the results of the environmental impact assessment reviews. If approved, project construction could commence in June 1994.

If constructed, the proposed Canadian project on Battle Creek would deplete average annual Battle Creek flows near Chinook by about 2,100 af, a 7 percent reduction. Although the Canadian depletion is relatively small, in median flow years it could reduce availability and quality of inflows to the Montana project.

**Figure 6-15. Monthly streamflows for the Milk River at Nashua under the Canadian Development Scenario**



# MITIGATION MEASURES THAT COULD BE ADOPTED TO REDUCE ADVERSE EFFECTS

The Board or other agencies with permitting authority could require that certain measures be implemented to reduce or eliminate adverse environmental impacts. Most of the reservation applications contain no description of such measures, and the preceding impact discussion is based on the assumption that no mitigating measures would be implemented. In this section, DNRC identifies and analyzes some possible mitigating measures.

## CHANGE OF OPERATION AT FORT PECK

Storage in Fort Peck Reservoir could allow depletions from the lower Missouri River basin reservation to be distributed in a variety of ways, if reservoir operations criteria were changed. Flow increases from Fort Peck Dam during the summer could mitigate summer streamflow reductions and associated adverse effects to aquatic habitat and recreation caused by development of consumptive use reservations. To make up the difference, releases from the reservoir in winter, when flows in the lower river are usually highest, would have to be reduced slightly. In this section, DNRC examines the consequences of such an action. Figure 6-16 shows streamflow estimates at the Montana/North Dakota under this scenario. Figure 6-17 shows Fort Peck elevation changes that would occur.

Winter recreation opportunities on or along the Missouri River would not change if operation of Fort Peck Dam is changed to offset downstream summer flow reductions. Such a change of operation would reduce existing high winter flows by several hundred cubic feet per second, which would represent approximately 5 to 10 percent of present winter flows.

Fort Peck Reservoir elevation losses of approximately 2 feet during dry years could make access to the water more difficult when reservoir levels are low. This effect would increase in very dry years when reservoir elevation would decrease approximately 4 feet. With a change of operations to increase flow from Fort Peck Dam during the summer, Fort Peck Reservoir elevations would decrease an additional 6 to 10 inches during the summers of very dry years over that resulting from full development of consumptive use reservations granted by the Board for the upper Missouri River basin, intensifying effects of low water levels on the reservoir. Access to the reservoir could become more difficult or impossible when consecutive dry years limit reservoir refilling.

## ADDITIONAL MEASURES

DNRC identified other impacts that could be reduced by implementing certain measures. Table 6-43 lists these impacts and measures that could reduce or eliminate them.

# IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

In this discussion, irretrievably committed resources are those that would be lost as a result of the water reservations. For example, hydropower that could not be produced because water was diverted would be lost, but hydropower production theoretically could resume if diversions were to stop.

Irreversible commitment of resources refers to the loss of resources with either no possibility of reclaiming them or loss for long periods of time, such as eroded topsoil or concrete used in building dams.

## WATER AVAILABILITY

Granting reservations for consumptive uses would commit water for future irrigation and municipal use. Committing water for these uses may preclude other future uses of the water, which would be irretrievable commitment for the duration of the reservation. However, provisions of the Water Use Act require the Board to review reservations at least every 10 years. If the objectives of the reservation are not being met, the Board may change, extend, modify, or revoke the reservation.

Reservations of water for instream use also may preclude future uses of the water. However, water reserved for instream use is not necessarily permanently unavailable for other uses. The Board may reallocate part or all of an instream flow reservation to another qualified reservant if the Board finds that the water is not required for its original purpose and that the need for the new use outweighs the need for the original reservation. The Board also may revoke or modify the reservation if the reservation is later found to exceed the flows necessary to meet the purpose of the reservation. Water made available in this way could be appropriated for other uses.

## WATER QUALITY

Water quality could diminish in aquifers due to excessive groundwater pumping for irrigating projects and excessive migration of poor quality water from adjacent aquifers or poorer quality surface

**Figure 6-16. Computed streamflows in the Missouri River at the Montana-North Dakota border if Fort Peck Reservoir is operated to shift flow reductions under the Consumptive Use Alternative to the months December, January and February**

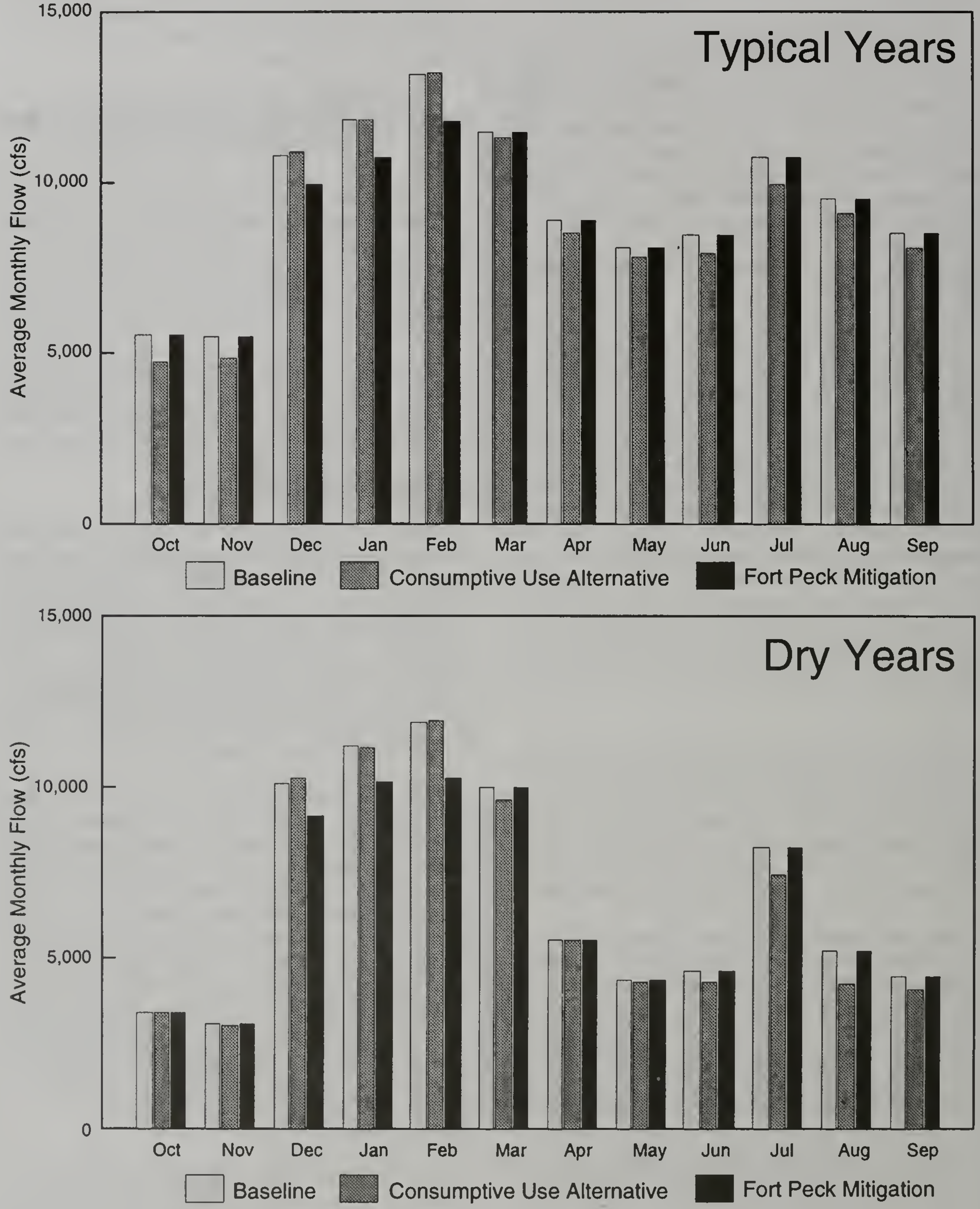


**Figure 6-17. Fort Peck Reservoir elevations under the Fort Peck Mitigation Scenario**

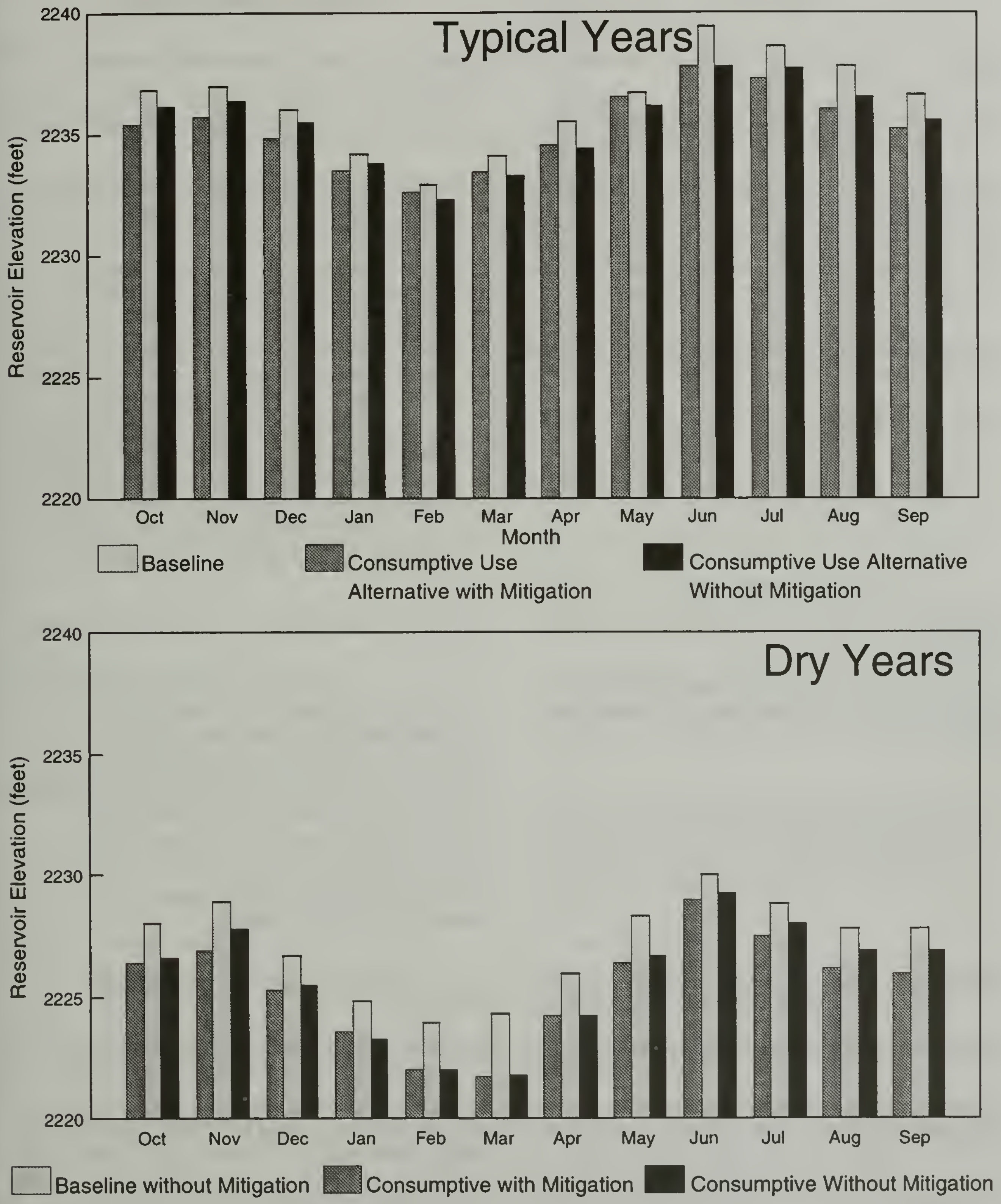


**Table 6-43. Measures that could be adopted to reduce impacts**

| Type of Impacts | Measures to Reduce Impacts |
|---|---|
| Irrigation projects conflict with existing land uses, such as residences, highways, and recreation sites | Redesign the project to reduce conflicts, especially on project VA-02. |
| Diversions for irrigation projects could create hazards to recreational boaters, possibly at project CBI-13 | Provide adequate warning to boaters and floaters along river above and below diversion. |
| Construction crews for large irrigation projects could displace current users at recreation areas used for temporary housing locations | Consultation between project developers and recreation managers and implementation of managers' recommendations |
| Stream channels could be altered downstream from reservoirs that alter streamflow patterns and trap sediment | Develop a reservoir operation plan which helps to preserve desirable stream channel characteristics. |
| Sediment would be introduced to streams during construction of dams and/or diversions | Conduct instream construction activities during periods of low flow. Build temporary coffer dams around instream construction sites to limit the transport of sediment. |
| Fish could be killed in pumps and diversions | Reduce intake velocities below the swimming speed for game fish and species of special concern in the affected stream reach. On the lower Missouri River, use USFWS recommendations to protect the endangered pallid sturgeon, including screening of intakes with 1/4-inch mesh and having intake velocities less than 1/2 ft/sec, or placing intakes at depths of 15 feet or more. |
| Reductions in flow affecting aquatic habitat in lower Missouri River | Change Fort Peck Reservoir operations to offset summer reductions. |
| Historical, archaeological, or paleontological resources could be destroyed or important information lost as a result of project construction | 1) Have known sites evaluated by a person qualified to determine site significance. This may involve consultation with Indian tribes, state and federal land managers, and the State Historic Preservation Office.<br>2) Survey projects proposed on undisturbed land for the presence of sites prior to project development and have site significance determined by a qualified person.<br>3) Avoid significant sites by project construction and operation wherever possible by adjusting location of equipment and field boundaries.<br>4) Collect and record information contained where important sites cannot be avoided. |
| Waterlogging of soils due to poor soil drainage | Install artificial drainage systems to facilitate soil drainage. |
| Sediment introduced from construction of projects | Revegetate disturbed areas to reduce erosion. |
| Decreased soil productivity from mixing soil layers when burying pipelines | Double-lift soil during trenching for large pipelines: excavate, store, and replace top 12 inches separate from subsoil. Remove large rocks prior to topsoil replacement. |
| Soil compaction and/or rutting from heavy equipment used to install pipelines | Retain stubble on working side of pipeline. Suspend construction during wet periods. Conduct post- construction deep ripping of soil along working side of pipeline. |

| | |
|---|---|
| Erosion on steep slopes and stream banks from pipeline construction | Clear vegetation immediately before pipelineconstruction. Install cross ditch and berm structures to divert water flow away from pipeline trench. In severe cases, install sack breakers or subdrains to force seepage to surface. Recontour to original slope and promptly revegetate. Use jute mesh on highly erodible soils with slopes of 10 percent or more. |
| Conflicts between reservants and existing water users over available water | Install measuring devices. Hire a water commissioner to monitor diversions and allocate water in accordance with water rights. |
| Salinity increase from local irrigation projects | Design effective irrigation systems and monitor increase. |
| Destruction of grouse leks, heron rookeries | Conduct studies of proposed projects to determine if leks or rookeries are present. If present, leave lek and buffer strip (100 meters) around lek or leave rookery. |
| Disturbance of grouse leks close to agriculture activity | Avoid farming activities in the early morning within 1/2 mile of leks during the grouse-breeding season. Peak displaying and mating by grouse takes place in the early morning from dawn to 7:00 a.m. |
| Electrocution of raptors in project powerlines | Use “raptor safe” design of powerlines to eliminate electrocution. |
| Disturbance of nesting raptors | Avoid farming activities within 1/2 mile of raptor nests during the nesting and brood-rearing period (March-July). Nests screened from activity by terrain and trees would be less susceptible to disturbance and, therefore, could be approached to within 1/4 mile. (Raptors, like other wildlife, usually become accustomed to human disturbance, particularly if the disturbance is consistent and follows regular patterns.) |
| Killing big game to alleviate crop damage | Fence haystacks against deer. Use nonlethal means such as noise or herding to keep wildlife away from crops. Regulate livestock grazing adjacent to crop fields to allow adequate amounts of forage to sustain wildlife over winter. |
| Proliferation of noxious weeds | Consult with the county weed board to determine the probability that noxious weeds would become a problem. Monitor for the initial appearance of noxious weeds. Eradicate initial colonies of noxious weeds before they spread, using methods recommended by the county weed board. |
| Exiting wells made unusable by reducing water levels | Drill replacement wells. |
| Riparian vegetation cleared to make project fields | Redesign project to avoid riparian vegetation. Leave strip of riparian land adjacent to stream to slow erosion. |
| Declining groundwater levels or diminishment of groundwater quality due to withdrawal of water by wells | Decrease pumpage by rotating use between wells or limiting withdrawals. |
| Conflicts between surface water and groundwater users | Install meters at wellheads. Monitor water levels and water quality at wells and surface water bodies. Regulate pumpage based on observed impacts or trends in water levels or water quality. |
| Drawdown could adversely affect lakes and wetlands | By consensus of affected parties, determine maximum acceptable drawdown. Consider annual variation in precipitation and water levels in making this determination. |

waters. These impacts would be reversible if withdrawals are curtailed or stopped, but the reversal could take decades due to the slow rate at which groundwater moves.

## SOILS

Soils could be lost through erosion, an irreversible loss of resource. Irretrievable commitment of soil quality would be made where native rangeland and riparian land are converted to irrigation, and where rangeland is permanently occupied by facilities needed to develop and use municipal reservations.

## LAND

The conversion of rangeland to irrigated cropland; construction of pipelines, canals, and powerlines; and flooding of land by reservoirs would irretrievably commit affected land to these uses during project life span. Instream reservations would have no irretrievable land use effects. Construction of reservoirs and municipal waterworks are generally irreversible land use commitments.

Land subsidence is a possible consequence of excessive withdrawals of groundwater from aquifers, especially if they are confined. The resulting impacts would be irreversible.

## FISHERIES AND AQUATIC HABITAT

Aquatic habitat and fisheries could be irretrievably lost or damaged, especially during periods of low flow, as reserved water is consumed for irrigation and municipal projects. Such effects would be reversible if reserved consumptive rights were abandoned permanently and the reserved water returned to the affected streams. Reservations for instream uses would not cause a loss or damage to aquatic resources.

## WILDLIFE

Conversion of wildlife habitat to irrigated agriculture and resulting reductions in wildlife numbers would commit some resources irretrievably. Irretrievable commitments would include crops damaged by wildlife depredation and habitat lost to cultivation while fields are being irrigated and managed to produce crops. Theoretically, the eventual cessation of irrigation followed by gradual reversion to native plant communities would result in reestablishment of native habitat for species unable to use irrigated croplands for food and cover.

If irrigated cropland is abandoned, big game animals would continue to use it. Predation complaints would decrease, however, and there would be less need for control measures such as damage hunts. Landowners usually are more tolerant of big game use of native range and noncultivated fields than they are of losses to high-value cultivated crops.

## VEGETATION

Native plants would be eliminated when rangeland and riparian land are converted to cropland. Sensitive plants at project sites would be irretrievably lost. If cropland is later abandoned, native plants could eventually become reestablished, but this could take decades. Native grasslands could be reestablished more quickly by reseeding. Losses of wooded riparian communities might be irretrievable. Riparian trees, such as plains cottonwood and peachleafed willow, require flooding or bank erosion and sediment deposition to become established—processes that may no longer be occurring at many project sites.

Wetland vegetation and associated animal life may be irretrievably and irreversibly lost in areas where wetlands sustained by groundwater are affected by an excessive lowering of the water table or are filled.

## HISTORICAL, ARCHAEOLOGICAL, AND PALEONTOLOGICAL RESOURCES

Construction of irrigation or municipal projects might cause an irreversible\irretrievable loss of historical, archaeological, or paleontological materials. These materials could lead to a better understanding of Montana's past. No known significant sites would be irreversibly committed as a result of the reservations. Instream flow would not affect these resources.

## RECREATION

Use of reserved water for irrigation and municipal projects would cause the irretrievable loss of this water for recreation during the period of withdrawal on some streams. This impact could be reversed if reserved water rights were abandoned and water returned to the affected stream. Reservations for instream use would not diminish recreational resources.

## ENERGY AND MATERIALS

Energy and fuel committed to development and operation of irrigation and municipal reservations would be permanently lost. Some materials used in irrigation development, such as irrigation pipe and sprinklers, could be retrieved in the future and reused or recycled. Consumptive use projects would annually require up to 31.1 GWh of electric power and 23,096 gallons of diesel fuel for pumps, which would be irretrievably and irreversibly lost.

## SOCIOECONOMIC RESOURCES

No socioeconomic resources would be irretrievably or irreversibly lost.

# IRRETRIEVABLE LOSSES OF NATURAL RESOURCES AND DEVELOPMENT OPPORTUNITIES RESULTING FROM FAILURE TO RESERVE WATER

The Board's decision criteria require consideration of whether failure to reserve water would result in irretrievable loss of natural resource development opportunity (36.16.107B 4d ARM). If reservations for instream flow and consumptive uses are not granted, there would be no loss of opportunities for water development where water is physically and legally available. Such development could take place under the water use permit system. Depending on the location; timing, and amount of water diverted, new water use permits could cause a direct, irretrievable loss of water quantity, water quality, fisheries, and opportunities for recreation. They also could indirectly affect riparian vegetation and wildlife habitat.

Reservations for instream flow are the only way to protect streamflow for water quality, fish, and recreation on streams where such reservations are requested. Failure to grant reservations for instream flow could result in losses to these natural resources. The Board can reallocate an instream reservation in the future upon finding that all or part of the reservations for instream flow is not required for its purpose, and that another applicant had shown a need outweighing that of the original reservant.

Development opportunities also could be lost if downstream states receive rights to Missouri River water that originates in Montana. The reservations proceeding was intended by the legislature to protect water for Montana's future needs. Information pertaining to project location and water requirements in the reservation applications could be used in place of reservations as evidence of Montana's future water needs in negotiations or litigation with downstream states.

If the Board approves reservations for instream flow and reservations for consumptive use, less water would be available for future appropriation. As a consequence, development opportunities could be lost at least temporarily, but natural resources would not be irretrievably committed. If no reservations were granted for municipal use, municipalities could condemn water rights.

## CHAPTER SEVEN

# BOARD DECISION CRITERIA

The decision of whether to grant or deny the requested water reservations rests with the Board. To reach its decision, the Board will need to consider the environmental impacts described in Chapter Six and evaluate the applications based on the statutory criteria explained below.

## QUALIFICATIONS AND PURPOSE

Before it can grant a reservation, the Board must find that the applicant is qualified to reserve water and that the purpose of the reservation is a beneficial use (Section 85-2-316(1) and 85-2-316(4)(a)(i), MCA; ARM 36.16.107B(1)). A qualified applicant is any state or political subdivision or agency of the state or federal government. Water may be reserved for existing or future beneficial use or to maintain a minimum flow, level, or quality of water.

## NEED

A reservation can be granted only if the Board finds that the reservation is needed (Section 85-2-316(4)(a)(ii), MCA). A reservation is needed if "there is a reasonable likelihood that future instate or out-of-state competing water uses would consume, degrade, or otherwise affect the water available for the purpose of the reservation" (ARM 36.16.107B(2)(a)), or if "there are constraints that would restrict the applicant from perfecting a water permit for the intended purpose of the reservation" (ARM 36.16.107B(2)(c)).

## AMOUNT

The Board must determine the amount of water needed to fulfill the purpose of the reservation (Section 85-2-316(4)(A)(iii), MCA). This amount must be based on "accurate and suitable" methods and assumptions. The Board also must find that there are no "reasonable cost-effective measures that could be taken within the reservation term to increase the use efficiency and lessen the amount of water required" (ARM 36.16.107(3)).

## PUBLIC INTEREST

The Board must find that the reservation is in the public interest (Section 85-2-316(4)(a)(iv), MCA). In making this determination, the Board must weigh and balance (a) whether the expected benefits of applying the reserved water to beneficial use are reasonably likely to exceed the costs; (b) whether the net benefits associated with granting a reservation exceed the net benefits of not granting the reservation; (c) whether there are no reasonable alternatives to the proposed reservation that have greater net benefits; (d) whether failure to reserve the water will or is likely to result in an irretrievable loss of a natural resource or an irretrievable loss of a resource development opportunity; and (e) whether there are no significant adverse impacts to public health, welfare, and safety.

The Board also may consider other factors it finds relevant (ARM 36.16.107B(4)).

## DILIGENCE

If the purpose of the reservation requires construction of a storage or diversion facility, the applicant shall establish to the satisfaction of the Board that there will be progress toward completion of the facility and accomplishment of the purpose with reasonable diligence in accordance with an established plan (Section 85-2-316(5), MCA).

## NO ADVERSE EFFECT ON SENIOR WATER RIGHTS

The proposed reservations must not adversely affect water rights in existence at the time of adoption (Section 85-2-316(9), MCA). A reservation cannot be granted if the record of the contested case hearing shows that the exercise of senior water rights would be adversely affected. It should be noted that the Board has the option to subordinate the reservations to water use permits issued after the reservation priority date of July 1, 1985, for reservations in the lower Missouri River and Milk River subbasins and Sheridan County Groundwater Area, and July 1, 1989, for reservations in the Little Missouri River subbasin. The Board, however, must find that such subordination would not interfere substantially with the purpose of any reservation (Section 85-2-331(4), MCA).

## CRITERIA FOR THE BOARD'S DECISION

In the following sections, applications are briefly reviewed in light of the Board's criteria for granting reservations. During the contested case hearing, individual applicants have an opportunity to present additional information showing how they have met these criteria.

## QUALIFICATIONS AND PURPOSE

### CONSERVATION DISTRICTS

Conservation districts are political subdivisions of the state that were organized under the State Conservation Districts Act (Section 76-15-101, et seq., MCA). The primary purpose of reservations for the conservation districts is to provide water for irrigation, which is a beneficial use as defined in Section 85-2-102(2)(a), MCA.

### MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS

DFWP is an agency of the state. The primary purpose of the requested reservations is to maintain instream flows to protect fish and wildlife and to sustain adequate levels of water quality. These are beneficial uses under Sections 85-2-102(2)(a) and 85-2-316(1), MCA and ARM 36.16.102(3).

### MUNICIPALITIES

Incorporated municipalities are political subdivisions of the state. The purpose of the municipal reservations is to reserve water for future municipal growth including domestic water supplies; irrigation of lawns, parks, and city grounds; and commercial and industrial uses. Municipal use is defined as a beneficial use in Section 85-2-102(2)(a).

### WATER DISTRICTS

Water and sewer districts are units of local government (Section 7-13-220(3), MCA). The purpose of the Hill County Water District's reservation application is to supply water for rural domestic use. Domestic use is defined as a beneficial use in Section 85-2-102(2)(a).

## NEED

### CONSERVATION DISTRICTS

Reservations would allow conservation districts to establish an early priority date for water to be used in the future. If the conservation districts are not granted water reservations, they still might be able to develop proposed projects through the water permitting process. Permits generally require that the development be completed in less than 10 years. However, due to present economic constraints, the irrigation development proposed by the conservation districts may not occur for some time. In the meantime, if the needed water is not reserved, it could be appropriated by competing users in Montana. Downstream states may make water claims that could affect water use in Montana, but an interstate allocation proceeding in the Missouri River basin is unlikely in the near future. However, competing water users, including applicants who have applied to reserve water for instream flow purposes, could limit the amount of water available for future appropriation.

### MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS

Under Montana law, a water right for instream uses can be secured only by obtaining a water reservation. A temporary water leasing program is underway that allows leasing of existing water rights on 20 streams for instream flows in order to maintain or enhance the fisheries. This pilot program is designed to relieve stress to fisheries in streams that are subject to low flows. Therefore, its applicability is limited. If DFWP does not obtain a reservation, the water it is requesting could be appropriated for consumptive uses. In some instances, this could have severe detrimental effects on fish, wildlife, recreation, and water quality.

### MUNICIPALITIES AND WATER DISTRICTS

A reservation is the only means to reserve water that will be needed to meet future municipal and rural growth in the lower Missouri River basin. In the future, all available water in the basin may be appropriated by competing agricultural, industrial, and instream users. Without a reservation, municipalities and water districts might have to go through a costly process of buying or condemning existing water rights to meet increasing demands.

## AMOUNT

### CONSERVATION DISTRICTS

The amounts of water requested by the conservation districts are based on the requirements of individual irrigation projects (Table 3-1). Basically, the amount of water needed for each project was calculated by multiplying the project acreage by the estimated water requirement of the crop to be grown and then dividing this number by the irrigation system efficiency. Four general types of irrigation systems were included in the conservation district applications—center pivot sprinklers, side-roll sprinklers, hand-line sprinklers, and water-spreading systems.

The Blaine and Liberty County Conservation districts' applications include water storage projects. The design of these projects incorporates the intended use of the reservoir, estimated water yields of the drainage, reservoir evaporation, and dam size. The design for the Battle Creek Reservoir project BL-181 did not take into account potential future Canadian water development. The predicted reservoir yield was used in determining the amount of land that could be irrigated.

In developing the applications, the conservation districts and DNRC examined many potential irrigation projects. However, only the projects considered to be economically feasible at least 10 percent of the time were included in the final applications. In the draft EIS, all proposed projects in the application are included under the Consumptive Use Alternative, but the Combination Alternative was designed to include only the proposed projects that would be economically feasible at least 50 percent of the time.

Irrigation projects were included in a conservation district's application if sufficient water is physically available at the point of diversion to satisfy that project. On some streams where there is more than one proposed irrigation project, the total proposed diversions would exceed the flow of the stream during dry years.

### MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS

DFWP used several different methods to determine the amount of streamflow necessary to protect fish, wildlife, recreation, and water quality, as described in Appendix C. Table 3-2 identifies the amount of water DFWP requested. On some gauged streams (Table 5-1), DFWP requested more than the maximum allowed under Section 85-5-331, MCA, which is half the average annual flow.

DFWP based its request on the Wetted Perimeter Inflection Point (WETP) method in cold water streams in the Milk River drainage and riffles in the Missouri River. This method determines the amount of water needed to cover riffle areas in specific stream reaches. DFWP proceeded under the belief that riffles are the most productive areas of a stream, where propagation and growth of fish-food organisms occur. If enough flow remains in a stream to keep riffle areas wet, then most of the food-producing areas of a stream will be maintained. Generally, the amount of water requested on streams where the WETP method was used is the amount required to cover riffles. Reserving this amount of flow also would protect other types of stream habitat, such as pools and bank cover.

The WETP method provides a reasonable estimate of the amount of stream bottom that remains wet in riffles at specific streamflows. However, on streams where DFWP used this method, it has not been demonstrated that there is a precise relationship between wetted perimeter and the maintenance of aquatic habitat, or the number and total weight of fish a stream can support. A recent study by Lohr (1993) showed that, "Reductions in stream discharge affected abundance of fish-food organisms primarily through declines in riffle area and invertebrate drift rate, with the greatest reduction occurring when stream discharge was below the wetted perimeter inflection point. Such reductions may potentially restrict growth of older trout and abundance of young individuals." Lohr studied and compared food production and abundance to flows in two cold water trout streams in Park and Gallatin counties. In its application, DFWP generally identified two flow levels—the upper and lower inflection points. Flow rates above the upper inflection point would maintain optimal habitat conditions, while flows below the lower inflection point would result in rapidly declining fish food production. Inflection points are discussed in Appendix C.

The Fixed Percentage Method was used on one stream reach. Desirable flow amounts are assumed to equal a fixed percentage of the estimated flow. While this method can be used as a general indicator of flows necessary to protect aquatic habitat, the assessment it provides is less sensitive to conditions in individual stream reaches than the WETP method.

The flow volumes DFWP requested in the Missouri River are based in part on the amount of water necessary to protect spawning and rearing habitat for rainbow trout in a side channel immediately downstream from Fort Peck Reservoir, and for sauger farther downstream. These estimates of instream flow needs entailed use of a computer modeling technique that is a part of the wetted perimeter analysis.

In the Poplar River drainage, DFWP defined a relationship between spring flow rate and spawning success for walleye and northern pike and used this information to request instream flows sufficient to support the fishery. This approach is among the most reliable methods for determining instream flow needs but is very expensive and time consuming. Factors other than flow rates may limit fish populations on some streams, and this approach would not be appropriate in those instances.

In warm water streams in the Poplar River drainage and the Milk and Little Missouri subbasins, DFWP used the base flow approach (see Appendix C). This method would leave a small amount of water in the stream channel to help ensure fish survival, but, as with the WETP method, there is no precisely demonstrated relationship between the instream flow requested and maintenance of aquatic habitat or the number or total weight of fish that streams would support under such a flow regime.

### MUNICIPALITIES AND WATER DISTRICTS

Each municipality and water district has different water requirements. In general, the municipalities and Hill County Water District based their reservation requests on the estimated amount of water that their respective service area populations will need by the year 2035. Future needs were generally calculated by multiplying the city's or district's predicted service area population in 2035 by the expected water consumption rate per person for that area. This was then compared to the existing reliable water supply and water rights to determine how much water to request. Practical considerations regarding each city's water supply and distribution systems also were taken into account in determining the amount to request. In some instances, municipalities are requesting reservations for new water supplies due to problems with present sources. Three municipalities requested water for irrigating parks. The amounts requested by the municipalities and Hill County Water District are summarized in Table 3-3.

The municipal and water district applications were prepared by a private engineering firm with DNRC reviewing its methods. All population projections were based on figures from the 1980 census. However, expected population growth rates in lower Missouri River basin municipalities are modest, with population declines possible. Information from the 1990 census and more recent population projections suggests that future population estimates based on the 1980 census are excessive, meaning that less water will be required than the amount applied for by the municipalities.

## PUBLIC INTEREST

In this section, DNRC presents two types of cost-benefit analyses to assist the Board in evaluating the proposed reservation requests. The first compares the relative costs and benefits under different combinations of water reservation requests as specified in the alternative criteria discussed in Chapter Five. The second type of cost-benefit analysis examines the social net benefits of individual water reservation requests. These analyses are general because actual costs and benefits cannot be known until after the Board makes its final decision, given that the Board has the authority to change proposed management plans of the conservation districts and municipalities and to specify the amount of water granted to applicants for consumptive use and instream flows.

### BENEFITS AND COSTS UNDER THE ALTERNATIVES

The cost-benefit analysis for the alternatives focuses on the economic consequences of establishing priorities and granting specific water reservations. The net benefits and costs presented in this analysis are based on a 70-year planning period and a 4.6 percent real discount rate.

Before presenting the results of the cost-benefit analysis for the different alternatives, it is important to restate a few crucial points that were presented earlier in this EIS. First, reservation requests in the Sheridan County Groundwater Area are not included in the Consumptive Use, Combination, Instream, and No Action alternatives, but are analyzed separately in a set of alternatives labeled Grant All, Partial Granting, and Coordinated Groundwater Development.

Second, the Consumptive Use, Combination, and Instream alternatives were modeled to include water depletions resulting from proposed water reservations in the lower Missouri River basin and from water reservations, which were granted but not yet used in the upper Missouri River basin. Under the No Action Alternative, the only water depletions modeled were those resulting from water reservations that were granted in the upper Missouri River basin. Since the economic feasibility of the water reservations in the upper basin was discussed in a separate EIS, this chapter discusses only the economic feasibility of the proposed water reservations in the lower Missouri River basin.

## BENEFITS

### NEW IRRIGATION

In this analysis, the value of water for irrigation is the difference between the net revenues from the existing dryland farming or ranching operation and from the proposed irrigated alfalfa-barley farming operation. These water values do not account for indirect costs or benefits or for transfers in wealth that may occur. A detailed description of the methodology used for this analysis is in Goroski (1993) and the DNRC Methodology Manual (1991).

The irrigation benefits shown in Table 7-1 are the median values today of 70 years of incremental net revenues, which would occur as a result of developing the proposed irrigation projects included in each alternative. In other words, DNRC estimated the present value of incremental net revenues over a 70-year period under 300 different scenarios to account for variability in future crop prices, production costs, and crop yields for each irrigation proposal, and based the estimate of the water's value on the median of the 300 net present values. This means that half of the 300 scenarios analyzed have higher net returns and half have lower net returns.

### INSTREAM USES

None of the reservations included under the alternatives would increase the value of water left instream, but some could prevent future instream flow depletions, thereby maintaining the existing value of instream water. Under average water conditions, current annual hydropower production at federal dams in downstream states is 9,160 GWh/year. The value of this hydroelectric power, based on costs of 5 and 10 cents/kWh, is $460 to $920 million per year. Water quality and channel maintenance also contribute to value of instream water, but these values have not been quantified.

### MUNICIPAL USE

Water for municipal use is worth at least what people are now paying for it. DNRC used Hill County Water District's rate of $2.68 per thousand gallons as an estimate of this value. The municipal net benefits shown in Table 7-1 are the value today of 70 years of the proposed municipal use valued at $2.68 per thousand gallons, less costs. Total municipal net benefits are $43.03 million, which was estimated with a 4.6 percent real discount rate. Municipal benefits are the same under all alternatives except the No Action Alternative, assuming that the amount of requested municipal water is actually needed. However, the amount of water requested by some municipalities may be excessive. Given DNRC's estimate for future water needs (Appendix K), total municipal benefits would be $8.42 million.

## COSTS

### REDUCED HYDROPOWER PRODUCTION

Every alternative that would result in lower streamflows would reduce power production at the five lower Missouri River dams. Annual losses of hydropower production under each alternative are shown in Table 6-35. Table 7-1 shows what it would cost today to replace 70 years of lost generation under the alternatives at 4.6 percent real discount rate. The net costs of reduced hydropower production caused by the proposed lower Missouri River basin projects ranges from $2.21 million under the Instream Alternative to $39.05 million under the Consumptive Use Alternative. There would be no net costs under the No Action Alternative. This assumes replacement power is valued at 5 cents/kWh.

The cost of the lost hydropower production would be borne largely by ratepayers in downstream states. Montana ratepayers, of course, will share a portion of these costs.

### REPLACING MUNICIPAL AND IRRIGATION POWER USE

DNRC's economic analysis used the current electric power rates in calculating costs of proposed irrigation and municipal projects. The cost of supplying this additional power would be higher than the current rates. The annual difference between the cost of

**Table 7-1. Benefits and costs under the alternatives ($ MILLIONS)(a)**

| | CONSUMPTIVE USE | COMBINATION | INSTREAM | NO ACTION | GAA (b) | PGA (b) | CGDA (b) |
|---|---|---|---|---|---|---|---|
| IRRIGATION | | | | | | | |
| Milk | 5.18 | 0.53 | 0.05 | 0.00 | - | - | - |
| Little Missouri | 1.52 | 0.42 | 0.10 | 0.00 | - | - | - |
| Sheridan County | - (c) | - | - | - | 23.88 | 2.07 | 3.85 |
| Lower Missouri | 18.99 | 19.87 | 1.45 | 0.00 | - | - | - |
| Total | 25.69 | 20.82 | 1.60 | 0.00 | 23.88 | 2.07 | 3.85 |
| MUNICIPAL | | | | | | | |
| Milk | 12.20 | 12.20 | 12.20 | 0.00 | - | - | - |
| Little Missouri | 0.64 | 0.64 | 0.64 | 0.00 | - | - | - |
| Sheridan County | - | - | - | - | 3.67 | 3.67 | 3.67 |
| Lower Missouri | 26.53 | 26.53 | 26.53 | 0.00 | - | - | - |
| Total | 39.36 | 39.36 | 39.36 | 0.00 | 3.67 | 3.67 | 3.67 |
| RECREATION | | | | | | | |
| Milk | -0.26 | -0.11 | -0.07 | 0.00 | - | - | - |
| Little Missouri | -0.22 | -0.16 | -0.05 | 0.00 | - | - | - |
| Sheridan County | - | - | - | - | unk | unk | unk |
| Lower Missouri | -6.55 | -3.72 | -0.23 | 0.00 | - | - | - |
| Total | -7.04 | -4.00 | -0.35 | 0.00 | unk | unk | unk |
| HYDROPOWER PRODUCTION | | | | | | | |
| Milk | - | - | - | - | - | - | - |
| Little Missouri | - | - | - | - | - | - | - |
| Sheridan County | - | - | - | - | - | - | - |
| Lower Missouri | - | - | - | - | - | - | - |
| Downstream | -39.05 | -21.94 | -2.21 | 0.00 | unk | unk | unk |
| Total | -39.05 | -21.94 | -2.21 | 0.00 | unk | unk | unk |
| REPLACEMENT POWER | | | | | | | |
| Milk | -0.08 | -0.07 | -0.02 | 0.00 | - | - | - |
| Little Missouri | -0.08 | -0.07 | -0.04 | 0.00 | - | - | - |
| Sheridan County | - | - | - | - | -3.96 | -0.18 | -0.47 |
| Lower Missouri | -6.33 | -2.98 | -0.54 | 0.00 | - | - | - |
| Total | -6.48 | -3.12 | -0.60 | 0.00 | -3.96 | -0.18 | -0.47 |
| **TOTAL** | **12.48** | **31.13** | **37.80** | **0.00** | **23.59** | **5.56** | **7.06** |

(a) Positive numbers represent net benefits and negative numbers represent net costs. All figures are the value today of 70 years of future impacts based on a 4.6 percent real discount rate. Values represent impacts from just the proposed lower Missouri River basin water reservations.

(b) GAA - Grant All Alternative, PGA - Partial Granting Alternative, CGDA - Coordinated Groundwater Development Alternative

(c) "-" indicates category does not apply in the alternative.

additional power for proposed projects and what applicants would pay for power is shown in Table 6-35. Table 7-1 shows the cost of the subsidy that the ratepayer would pay over 70 years. It would range from $0.78 million under the Instream Flow and Partial Granting alternatives to $10.44 million under the Consumptive Use and Grant All alternatives. Replacement power is assumed to be valued at 5 cents/kWh. There would be no additional replacement power costs under the No Action Alternative.

### REDUCED RECREATION

Lower flows also would reduce future water-based recreation below levels that would occur with present flow levels. The annual value of lost recreation due to lower flows under each alternative is shown in Table 6-33. Table 7-1 shows the cost today of 70 years of lost recreation, which would result from the proposed lower Missouri basin water reservations. Excluding the No Action Alternative where costs are zero, costs for lost recreation are highest under the Consumptive Use Alternative ($7.04 million) and lowest under the Instream Alternative ($.35 million).

## COMPARISON OF BENEFITS AND COSTS FOR DNRC'S ALTERNATIVES

Table 7-1 shows the costs and benefits associated with DNRC's alternatives. All of the alternatives with the exception of the No Action Alternative would increase consumptive use for irrigation and municipalities, result in lower streamflows for recreation and hydropower production and require replacement of electricity used by irrigation and municipal water systems. Assuming that all the water requested for the proposed consumptive use reservations is needed and available, net benefits would be increased by granting the reservations. In other words, the benefits of the consumptive uses exceed the costs of the instream flow losses. The net benefits are highest in the Instream and Grant All alternatives and lowest in the Consumptive Use and Partial Granting alternatives. Analysis of the No Action Alternative, which would grant no reservation requests in the lower Missouri River basin, shows no economic net benefits.

The Grant All, Partial Granting, and Coordinated Groundwater Development alternatives show that the proposed consumptive uses in the Sheridan County Groundwater Area have net benefits. These consumptive uses are likely to affect recreation and hydropower production because groundwater use could affect water levels in lakes and wetlands and flows in Big Muddy Creek and the Missouri River. However, as explained in Chapter Six, DNRC was unable to quantify these changes in flow and, consequently, was unable to quantify economic net costs.

Table 7-2 shows the benefits and costs that would result from reservation of water for municipal and irrigation purposes under each alternative. The costs to recreation and electric generation imposed by increased irrigation exceed the benefits by $25.31 million under the Consumptive Use Alternative and by $6.67 million under the Combination Alternative. The high costs are due to the large amounts of water consumed by the irrigation projects in these alternatives. Under the Instream Alternative, however, irrigation benefits exceed costs by $0.01 million.

**Table 7-2. Benefits and costs of reservations for irrigation and municipal uses ($ million)(a)**

| | Consumptive Use | Combination | Instream | No Action | GAA (b) | PGA (b) | CGDA (b) |
|---|---|---|---|---|---|---|---|
| Irrigation | | | | | | | |
| benefits | 25.69 | 20.82 | 1.60 | 0.00 | 23.88 | 2.07 | 3.85 |
| costs | -51.00 | -27.49 | -1.59 | 0.00 | unk | unk | unk |
| net | -25.31 | -6.67 | 0.01 | 0.00 | unk | unk | unk |
| Municipal | | | | | | | |
| benefits | 39.36 | 39.36 | 39.36 | 0.00 | 3.67 | 3.67 | 3.67 |
| costs | -1.57 | -1.57 | -1.57 | 0.00 | unk | unk | unk |
| net | 37.79 | 37.79 | 37.79 | 0.00 | unk | unk | unk |

(a) Positive numbers represent net benefits and negative numbers represent net costs.
All figures are the value today of 70 years of future impacts based on a 4.6 percent real discount rate.

(b) GAA - Grant All Alternative, PGA - Partial Granting Alternative, CGDA - Coordinated Groundwater Development Alternative

The total benefits attributable to municipal water use are relatively large compared to the costs incurred. This is a direct result of a high-value consumptive use that has only small impacts on instream uses. The net benefits of municipal water use with the exception of use by Plentywood, which is in the Sheridan County Groundwater Area, are $37.79 million. This assumes that the proposed amounts for municipal use are actually needed. The economic net costs to recreation and hydropower production resulting from reservations in the Sheridan County groundwater area are unknown.

### BENEFITS AND COSTS OF GRANTING RESERVATIONS FOR INDIVIDUAL PROJECTS

Reservations for future consumptive uses would help ensure that water will be available for future irrigation and municipal use. Reservations for instream uses would provide legal protection for recreation and downstream hydropower production. However, granting any reservation would impose costs by precluding other water uses. Benefits would be maximized if the net value of a water use is greater than that of any precluded water use.

Each consumptive use has at least potential conflicts with other uses. Many drainages in which there is not enough water to satisfy all the requested reservations have two or more consumptive use proposals. The consumptive requests may conflict with each other or with instream requests, either on the stream reach where the water is being requested or downstream. Consumptive use requests on a tributary also can conflict with other instream or consumptive use requests and existing hydropower uses downstream. Instream requests can conflict with consumptive use requests on the same stream or on tributaries upstream. When two or more reservation requests conflict, the cost of granting one request is the value of the foregone benefits of the others. On streams with three or more requests, the net benefits will be greatest from granting as many requests as possible, starting with the highest valued.

Tables L-1 and L-2 in Appendix L compare consumptive use water values with instream water values under two different replacement power cost assumptions and for different water availability. The cost of replacement power, which was calculated at 5 and 10 cents/kWh, affects both the values associated with reductions in hydropower production and the additional electric power required because of the proposed consumptive use projects.

Consumptive use water values were derived with methodology discussed in Goroski (1993) and the DNRC Methodology Manual (1991). The instream water values are the sum of hydropower and recreational values. A discussion of these instream flow values is included in Chapter Six and in Appendix L.

## REASONABLE ALTERNATIVES WITH GREATER NET BENEFITS

The alternatives presented in this EIS are only a few of many ways the Board could allocate water among the reservation applicants. Some other combination of reservations might have greater net benefits than any of the alternatives examined by DNRC. DNRC did not attempt to determine an optimal alternative but instead gave a range of alternatives to assist the Board in its evaluation of relative costs and benefits from the reservation requests.

Furthermore, DNRC did not attempt to redesign or modify any irrigation reservation request in order to increase net benefits, although, given site-specific information, the potential exists for obtaining greater net benefits. In particular, irrigation projects with serious land use problems could have greater net benefits if modified.

# APPENDIX A

## SUMMARY OF WATER RIGHT CLAIMS, PERMITS, AND PERMIT APPLICATIONS IN THE MISSOURI RIVER BASIN BELOW FORT PECK DAM

**Table A-1. Lower Missouri subbasin existing claims**

| DRAINAGE | PURPOSE | NUMBER | TOTAL RATE (cfs) | VOLUME (af) | LAND USED ON (acres) |
|---|---|---|---|---|---|
| MISSOURI RIVER | MUNICIPAL AND DOMESTIC | 33 | 37.2 | 6,865.7 | 339.0 |
| | IRRIGATION | 442 | 39,245.0 | 1,032,539.4 | 121,981.6 |
| | STOCK | 1,325 | 1,986.9 | 32,434.8 | 0.0 |
| | FISH AND WILDLIFE | 131 | 44.6 | 3,003.2 | 0.0 |
| | POWER GENERATION | 1 | 415.0 | 2,300.0 | 0.0 |
| | OTHER | 30 | 286.2 | 86,258.6 | 0.0 |
| | DRAINAGE TOTALS | 1,962 | 42,014.9 | 1,163,401.7 | 122,320.6 |
| REDWATER RIVER | MUNICIPAL AND DOMESTIC | 3 | 1.8 | 1,053.6 | 5.0 |
| | IRRIGATION | 222 | 226.1 | 24,556.5 | 14,961.3 |
| | STOCK | 822 | 0.1 | 396.4 | 0.0 |
| | FISH AND WILDLIFE | 20 | 0.0 | 4.2 | 0.0 |
| | POWER GENERATION | 2 | 0.0 | 99.0 | 0.0 |
| | OTHER | 1 | 0.7 | 50.0 | 0.0 |
| | DRAINAGE TOTALS | 1,070 | 228.6 | 26,159.6 | 14,966.3 |
| POPLAR RIVER | MUNICIPAL AND DOMESTIC | 7 | 30.0 | 1,028.3 | 1.8 |
| | IRRIGATION | 129 | 16,573.9 | 6,038,229.5 | 111,111.4 |
| | STOCK | 700 | 1,102.9 | 7,074.1 | 0.0 |
| | FISH AND WILDLIFE | 10 | 62.7 | 613.3 | 0.0 |
| | OTHER | 1 | 13.3 | 200.0 | 0.0 |
| | DRAINAGE TOTALS | 847 | 17,782.8 | 6,047,145.2 | 111,113.1 |
| BIG MUDDY CREEK | MUNICIPAL AND DOMESTIC | 11 | 4.9 | 1,390.3 | 50.7 |
| | IRRIGATION | 202 | 12,104.3 | 2,350,090.4 | 65,612.8 |
| | STOCK | 822 | 3,956.6 | 11,504.7 | 0.0 |
| | FISH AND WILDLIFE | 37 | 12,117.0 | 153,099.2 | 0.0 |
| | OTHER | 15 | 35.0 | 1,760.0 | 0.0 |
| | DRAINAGE TOTALS | 1,087 | 28,217.8 | 2,517,844.5 | 65,663.5 |
| SUBBASIN TOTALS | MUNICIPAL AND DOMESTIC | 54 | 73.9 | 10,337.9 | 396.5 |
| | IRRIGATION | 995 | 68,149.3 | 9,445,415.8 | 313,667.1 |
| | STOCK | 3,669 | 7,046.5 | 51,410.0 | 0.0 |
| | FISH AND WILDLIFE | 198 | 12,224.3 | 156,719.9 | 0.0 |
| | POWER GENERATION | 3 | 415.0 | 2,399.0 | 0.0 |
| | OTHER | 47 | 335.2 | 88,268.6 | 0.0 |
| | GRAND TOTALS | 4,966 | 88,244.1 | 9,754,551.0 | 314,063.5 |

Table A-2. Lower Missouri subbasin permits 1973 through June 30, 1985

| DRAINAGE | PURPOSE | NUMBER | TOTAL RATE (cfs) | VOLUME (af) | LAND USED ON (acres) |
|---|---|---|---|---|---|
| MISSOURI RIVER | MUNICIPAL AND DOMESTIC | 7 | 16.9 | 5,815.1 | 3.4 |
| | IRRIGATION | 98 | 680.7 | 48,353.9 | 20,264.9 |
| | STOCK | 60 | 1.0 | 482.6 | 0 0 |
| | FISH AND WILDLIFE | 10 | 0.2 | 142.5 | 0.0 |
| | OTHER | 2 | 0.3 | 9.0 | 0.0 |
| | DRAINAGE TOTALS | 177 | 699.2 | 54,803.1 | 20,268.3 |
| REDWATER RIVER | MUNICIPAL AND DOMESTIC | 1 | 0.3 | 100.0 | 0.0 |
| | IRRIGATION | 32 | 157.8 | 4,421.4 | 3,106.8 |
| | STOCK | 25 | 0.9 | 104.7 | 0.0 |
| | FISH AND WILDLIFE | 1 | 0.0 | 20.0 | 0.0 |
| | OTHER | 1 | 0.0 | 0.7 | 0.0 |
| | DRAINAGE TOTALS | 60 | 159.0 | 4,646.8 | 3,106.8 |
| POPLAR RIVER | MUNICIPAL AND DOMESTIC | 3 | 3.7 | 1,881.0 | 0.0 |
| | IRRIGATION | 21 | 40.5 | 5,526.7 | 2,443.0 |
| | STOCK | 29 | 0.0 | 88.9 | 0.0 |
| | FISH AND WILDLIFE | 3 | 0.0 | 23.9 | 0.5 |
| | POWER GENERATION | 1 | 0.0 | 5.0 | 0.0 |
| | OTHER | 1 | 2.2 | 2.0 | 0.0 |
| | DRAINAGE TOTALS | 58 | 46.4 | 7,527.5 | 2,443.5 |
| BIG MUDDY CREEK | MUNICIPAL AND DOMESTIC | 4 | 3.4 | 1,406.8 | 0.2 |
| | IRRIGATION | 41 | 136.8 | 11,116.5 | 5,671.8 |
| | STOCK | 46 | 0.0 | 189.4 | 0.0 |
| | FISH AND WILDLIFE | 22 | 0.0 | 646.0 | 40.0 |
| | OTHER | 7 | 2.6 | 109.7 | 2.0 |
| | DRAINAGE TOTALS | 120 | 142.8 | 13,468.5 | 5,714.0 |
| SUBBASIN TOTALS | MUNICIPAL AND DOMESTIC | 15 | 24.3 | 9,202.9 | 3.6 |
| | IRRIGATION | 192 | 1,015.8 | 69,418.5 | 31,486.5 |
| | STOCK | 160 | 1.9 | 865.6 | 0.0 |
| | FISH AND WILDLIFE | 36 | 0.2 | 832.4 | 40.5 |
| | POWER GENERATION | 1 | 0.0 | 5.0 | 0.0 |
| | OTHER | 11 | 5.1 | 121.4 | 2.0 |
| | GRAND TOTALS | 415 | 1,047.4 | 80,445.9 | 31,532.6 |

**Table A-3. Lower Missouri subbasin permits and applications June 30, 1985 through April 30, 1993**

| DRAINAGE | PURPOSE | NUMBER | TOTAL RATE (cfs) | VOLUME (af) | LAND USED ON (acres) |
|---|---|---|---|---|---|
| MISSOURI RIVER | MUNICIPAL AND DOMESTIC | 1 | 4.5 | 750.0 | 0.0 |
| | IRRIGATION | 17 | 118.2 | 8,569.0 | 3,409.0 |
| | STOCK | 23 | 0.0 | 243.6 | 0.0 |
| | OTHER | 5 | 47.3 | 1,903.3 | 790.5 |
| | DRAINAGE TOTALS | 46 | 169.9 | 11,465.9 | 4,199.5 |
| REDWATER RIVER | IRRIGATION | 1 | 2.8 | 0.0 | 115.0 |
| | STOCK | 11 | 0.0 | 146.1 | 0.0 |
| | OTHER | 1 | 0.0 | 24.0 | 24.0 |
| | DRAINAGE TOTALS | 13 | 2.8 | 170.6 | 139.0 |
| POPLAR RIVER | IRRIGATION | 3 | 4.7 | 385.9 | 217.0 |
| | STOCK | 2 | 0.0 | 2.2 | 0.0 |
| | FISH AND WILDLIFE | 1 | 0.0 | 2,230.0 | 0.0 |
| | DRAINAGE TOTALS | 6 | 4.7 | 2,618.1 | 217.0 |
| BIG MUDDY CREEK | MUNICIPAL AND DOMESTIC | 1 | 3.3 | 800.0 | 0.0 |
| | IRRIGATION | 12 | 39.4 | 3,334.0 | 1,629.9 |
| | STOCK | 33 | 0.0 | 213.6 | 0.0 |
| | FISH AND WILDLIFE | 1 | 0.0 | 37.0 | 0.0 |
| | OTHER | 1 | 5.6 | 625.0 | 133.0 |
| | DRAINAGE TOTALS | 48 | 48.3 | 5,009.7 | 1,762.9 |
| SUBBASIN TOTALS | MUNICIPAL AND DOMESTIC | 2 | 7.8 | 1,550.0 | 0.0 |
| | IRRIGATION | 33 | 165.1 | 12,288.9 | 5,370.9 |
| | STOCK | 69 | 0.0 | 605.5 | 0.0 |
| | FISH AND WILDLIFE | 2 | 0.0 | 2,267.0 | 0.0 |
| | OTHER | 7 | 52.9 | 2,552.3 | 947.5 |
| | GRAND TOTALS | 113 | 225.7 | 19,264.3 | 6,318.4 |

**Table A-4. Milk subbasin existing claims**

| DRAINAGE | PURPOSE | NUMBER | TOTAL RATE (cfs) | VOLUME (af) | LAND USED ON (acres) |
|---|---|---|---|---|---|
| MILK RIVER | MUNICIPAL AND DOMESTIC | 122 | 276.6 | 95,841.5 | 262.0 |
| | IRRIGATION | 1,989 | 26,963.8 | 1,120,854.6 | 683,300.0 |
| | STOCK | 8,860 | 7,366.6 | 2,734,163.0 | 0.0 |
| | FISH AND WILDLIFE | 2,695 | 2,638.1 | 730,932.5 | 2.0 |
| | POWER GENERATION | 80 | 0.0 | 79,506.3 | 0.0 |
| | OTHER | 88 | 476.8 | 801,929.6 | 47.3 |
| | DRAINAGE TOTALS | 13,834 | 37,721.9 | 5,563,218.5 | 683,609.4 |
| SAGE CREEK AND BIG SANDY CREEK | MUNICIPAL AND DOMESTIC | 34 | 78.4 | 1,022.7 | 63.4 |
| | IRRIGATION | 257 | 1,929.0 | 243,766.4 | 59,509.6 |
| | STOCK | 766 | 1,706.3 | 4,589.3 | 0.0 |
| | FISH AND WILDLIFE | 26 | 108.2 | 5,784.0 | 0.0 |
| | POWER GENERATION | 1 | 0.0 | 1,000.0 | 0.0 |
| | OTHER | 13 | 0.7 | 85.6 | 0.5 |
| | DRAINAGE TOTALS | 1,097 | 3,822.6 | 256,247.9 | 59,573.4 |
| BEAVER CREEK AND PEOPLES CREEK | MUNICIPAL AND DOMESTIC | 3 | 0.3 | 6.4 | 2.2 |
| | IRRIGATION | 698 | 13,316.0 | 2,815,717.3 | 199,526.6 |
| | STOCK | 1,719 | 3,631.0 | 2,562,488.1 | 0.0 |
| | FISH AND WILDLIFE | 600 | 3,510.3 | 42,879.4 | 0.0 |
| | OTHER | 5 | 29.4 | 24,318.5 | 0.0 |
| | DRAINAGE TOTALS | 3,025 | 20,487.1 | 5,445,409.7 | 199,528.9 |
| BATTLE CREEK FRENCH CREEK AND ROCK CREEK | MUNICIPAL AND DOMESTIC | 3 | 0.1 | 21.3 | 7.5 |
| | IRRIGATION | 224 | 1,481.5 | 168,645.5 | 56,805.1 |
| | STOCK | 2,928 | 0.0 | 1,669.2 | 0.0 |
| | FISH AND WILDLIFE | 1,812 | 0.0 | 11,172.0 | 0.0 |
| | OTHER | 2 | 0.0 | 0.5 | 6.2 |
| | DRAINAGE TOTALS | 4,969 | 1,481.5 | 181,508.5 | 56,818.8 |
| SUBBASIN TOTALS | MUNICIPAL AND DOMESTIC | 162 | 355.4 | 96,891.9 | 335.1 |
| | IRRIGATION | 3,168 | 43,690.3 | 4,348,983.8 | 999,141.4 |
| | STOCK | 14,273 | 12,703.9 | 5,302,909.6 | 0.0 |
| | FISH AND WILDLIFE | 5,133 | 6,256.6 | 790,767.9 | 2.0 |
| | POWER GENERATION | 81 | 0.0 | 80,506.3 | 0.0 |
| | OTHER | 108 | 507 | 826,334 | 54 |
| | GRAND TOTALS | 22,925 | 63,513.1 | 11,446,384.6 | 999,530.5 |

**Table A-5. Milk subbasin permits 1973 through June 30, 1985**

| DRAINAGE | PURPOSE | NUMBER | TOTAL RATE (cfs) | VOLUME (af) | LAND USED ON (acres) |
|---|---|---|---|---|---|
| MILK RIVER | MUNICIPAL AND DOMESTIC | 20 | 15.5 | 3,828.8 | 72.0 |
| | IRRIGATION | 198 | 645.9 | 71,880.0 | 31,349.1 |
| | STOCK | 306 | 0.2 | 1,142.6 | 3.0 |
| | FISH AND WILDLIFE | 68 | 0.0 | 606.1 | 2.0 |
| | OTHER | 48 | 0.5 | 337.0 | 330.0 |
| | DRAINAGE TOTALS | 640 | 671.1 | 77,794.6 | 31,756.1 |
| SAGE CREEK AND BIG SANDY CREEK | MUNICIPAL AND DOMESTIC | 5 | 2.0 | 1,215.1 | 0.0 |
| | IRRIGATION | 17 | 35.4 | 2,734.5 | 1,831.7 |
| | STOCK | 28 | 0.9 | 169.7 | 1.0 |
| | FISH AND WILDLIFE | 6 | 1.1 | 41.7 | 11.0 |
| | OTHER | 4 | 0.1 | 26.6 | 0.0 |
| | DRAINAGE TOTALS | 60 | 39.4 | 4,187.6 | 1,843.7 |
| BEAVER CREEK AND PEOPLES CREEK | IRRIGATION | 32 | 164.2 | 10,702.3 | 6,857.2 |
| | STOCK | 58 | 0.0 | 151.0 | 0.0 |
| | FISH AND WILDLIFE | 13 | 0.0 | 46.5 | 0.0 |
| | OTHER | 93 | 0.0 | 710.0 | 0.0 |
| | DRAINAGE TOTALS | 196 | 164.2 | 11,609.8 | 6,857.2 |
| BATTLE CREEK FRENCH CREEK AND ROCK CREEK | IRRIGATION | 12 | 70.3 | 5,602.9 | 2,411.1 |
| | STOCK | 56 | 0.0 | 127.5 | 0.0 |
| | FISH AND WILDLIFE | 25 | 0.0 | 264.8 | 0.0 |
| | OTHER | 16 | 0.0 | 76.7 | 0.0 |
| | DRAINAGE TOTALS | 109 | 70.3 | 6,071.8 | 2,411.1 |
| SUBBASIN TOTALS | MUNICIPAL AND DOMESTIC | 25 | 17.5 | 5,043.9 | 72.0 |
| | IRRIGATION | 259 | 915.8 | 90,919.7 | 42,449.1 |
| | STOCK | 448 | 1.1 | 1,590.7 | 4.0 |
| | FISH AND WILDLIFE | 112 | 1.1 | 959.1 | 13.0 |
| | OTHER | 161 | 0.6 | 1,150.3 | 330.0 |
| | GRAND TOTALS | 1,005 | 945.1 | 99,663.8 | 42,868.1 |

**TableA-6. Milk subbasin permits and applications June 30, 1985 through April 30, 1993**

| DRAINAGE | PURPOSE | NUMBER | TOTAL RATE (cfs) | VOLUME (af) | LAND USED ON (acres) |
|---|---|---|---|---|---|
| MILK RIVER | MUNICIPAL AND DOMESTIC | 2 | 1.6 | 622.6 | 0.0 |
| | IRRIGATION | 10 | 11.2 | 1,872.9 | 949.9 |
| | STOCK | 351 | 0.1 | 1,661.8 | 0.0 |
| | FISH AND WILDLIFE | 41 | 0.0 | 843.4 | 0.0 |
| | OTHER | 2 | 0.1 | 38.9 | 28.0 |
| | DRAINAGE TOTALS | 406 | 13.1 | 5,039.6 | 977.9 |
| SAGE CREEK AND BIG SANDY CREEK | STOCK | 19 | 0.0 | 63.0 | 0.0 |
| | FISH AND WILDLIFE | 1 | 0.0 | 3.0 | 0.0 |
| | DRAINAGE TOTALS | 20 | 0.0 | 66.0 | 0.0 |
| BEAVER CREEK AND PEOPLES CREEK | IRRIGATION | 1 | 0.0 | 1.9 | 2.0 |
| | STOCK | 147 | 0.0 | 622.7 | 0.0 |
| | FISH AND WILDLIFE | 30 | 0.0 | 74.5 | 0.0 |
| | OTHER | 1 | 0.0 | 255.0 | 170.0 |
| | DRAINAGE TOTALS | 179 | 0.0 | 954.1 | 172.0 |
| BATTLE, FRENCH AND ROCK CREEKS | STOCK | 121 | 0.0 | 205.8 | 0.0 |
| | FISH AND WILDLIFE | 11 | 0.0 | 19.6 | 0.0 |
| | DRAINAGE TOTALS | 132 | 0.0 | 225.4 | 0.0 |
| SUBBASIN TOTALS | MUNICIPAL AND DOMESTIC | 2 | 1.6 | 622.6 | 0.0 |
| | IRRIGATION | 11 | 11.2 | 1,874.8 | 951.9 |
| | STOCK | 638 | 0.1 | 2,553.3 | 0.0 |
| | FISH AND WILDLIFE | 83 | 0.0 | 940.5 | 0.0 |
| | OTHER | 3 | 0.1 | 293.9 | 198.0 |
| | GRAND TOTALS | 737 | 13.1 | 6,285.1 | 1,149.9 |

**Table A-7. Little Missouri subbasin existing claims**

| DRAINAGE | PURPOSE | NUMBER | TOTAL RATE (cfs) | VOLUME (af) | LAND USED ON (acres) |
|---|---|---|---|---|---|
| BEAVER CREEK | MUNICIPAL AND DOMESTIC | 2 | 0.4 | 285.0 | 1.0 |
| | IRRIGATION | 66 | 90.4 | 5,541.8 | 2,779.1 |
| | STOCK | 360 | 0.0 | 6.1 | 0.0 |
| | FISH AND WILDLIFE | 8 | 0.0 | 652.1 | 0.0 |
| | OTHER | 1 | 0.0 | 0.5 | 0.0 |
| | DRAINAGE TOTALS | 437 | 90.8 | 6,485.4 | 2,780.1 |
| LITTLE BEAVER CREEK | MUNICIPAL AND DOMESTIC | 3 | 0.5 | 39.5 | 1.0 |
| | IRRIGATION | 121 | 32.7 | 12,593.0 | 6,979.7 |
| | STOCK | 554 | 0.0 | 29.2 | 0.0 |
| | FISH AND WILDLIFE | 81 | 0.0 | 206.5 | 0.0 |
| | OTHER | 6 | 2.7 | 2,030.0 | 0.0 |
| | DRAINAGE TOTALS | 765 | 35.9 | 14,898.2 | 6,980.7 |
| BOXELDER CREEK | MUNICIPAL AND DOMESTIC | 6 | 0.0 | 11.0 | 5.7 |
| | IRRIGATION | 354 | 202.1 | 70,664.8 | 40,917.6 |
| | STOCK | 1,392 | 0.0 | 233.3 | 0.0 |
| | FISH AND WILDLIFE | 264 | 0.0 | 3,072.8 | 0.0 |
| | POWER GENERATION | 13 | 0.0 | 125.0 | 0.0 |
| | OTHER | 1 | 0.0 | 17.0 | 0.0 |
| | DRAINAGE TOTALS | 2,030 | 202.1 | 74,124.0 | 40,923.4 |
| LITTLE MISSOURI RIVER | MUNICIPAL AND DOMESTIC | 3 | 0.0 | 6.9 | 2.2 |
| | IRRIGATION | 452 | 391.1 | 118,477.7 | 77,618.0 |
| | STOCK | 1,827 | 0.0 | 373.7 | 40.0 |
| | FISH AND WILDLIFE | 282 | 0.0 | 2,215.0 | 0.0 |
| | POWER GENERATION | 1 | 0.0 | 0.0 | 0.0 |
| | DRAINAGE TOTALS | 2,565 | 391.1 | 121,073.3 | 77,660.3 |
| SUBBASIN TOTALS | MUNICIPAL AND DOMESTIC | 14 | 0.9 | 342.4 | 10.0 |
| | IRRIGATION | 993 | 716.3 | 207,277.3 | 128,294.4 |
| | STOCK | 4,133 | 0.0 | 642.3 | 40.0 |
| | FISH AND WILDLIFE | 635 | 0.0 | 6,146.4 | 0.0 |
| | POWER GENERATION | 14 | 0.0 | 125.0 | 0.0 |
| | OTHER | 8 | 2.7 | 2,047.5 | 0.0 |
| | GRAND TOTALS | 5,797 | 719.9 | 216,580.9 | 128,344.5 |

**Table A-8. Little Missouri subbasin permits 1973 through June 30, 1989**

| DRAINAGE | PURPOSE | NUMBER | TOTAL RATE (cfs) | VOLUME (af) | LAND USED ON (acres) |
|---|---|---|---|---|---|
| BEAVER CREEK | MUNICIPAL AND DOMESTIC | 1 | 0.4 | 250.0 | 0.0 |
| | IRRIGATION | 31 | 127.2 | 2,173.9 | 1,029.4 |
| | STOCK | 17 | 0.0 | 99.5 | 0.0 |
| | FISH AND WILDLIFE | 4 | 0.0 | 17.9 | 0.0 |
| | OTHER | 1 | 11.1 | 45.0 | 30.0 |
| | DRAINAGE TOTALS | 54 | 138.8 | 2,586.3 | 1,059.4 |
| LITTLE BEAVER CREEK | IRRIGATION | 12 | 14.5 | 1,001.6 | 792.0 |
| | STOCK | 33 | 0.0 | 143.5 | 0.0 |
| | FISH AND WILDLIFE | 2 | 0.0 | 30.0 | 0.0 |
| | OTHER | 3 | 0.0 | 174.0 | 153.0 |
| | DRAINAGE TOTALS | 50 | 14.5 | 1,349.1 | 945.0 |
| BOXELDER CREEK | IRRIGATION | 14 | 47.3 | 3,543.5 | 2,309.0 |
| | STOCK | 91 | 0.0 | 236.6 | 0.0 |
| | OTHER | 1 | 0.0 | 13.5 | 9.0 |
| | DRAINAGE TOTALS | 106 | 47.3 | 3,793.6 | 2,318.0 |
| LITTLE MISSOURI RIVER | IRRIGATION | 22 | 34.9 | 5,683.0 | 4,762.0 |
| | STOCK | 115 | 10.0 | 411.6 | 2.0 |
| | FISH AND WILDLIFE | 2 | 0.0 | 5.0 | 0.0 |
| | OTHER | 3 | 10.6 | 415.2 | 364.1 |
| | DRAINAGE TOTALS | 142 | 55.5 | 6,514.8 | 5,128.1 |
| SUBBASIN TOTALS | MUNICIPAL AND DOMESTIC | 1 | 0.4 | 250.0 | 0.0 |
| | IRRIGATION | 79 | 223.9 | 12,402.0 | 8,892.4 |
| | STOCK | 256 | 10.0 | 891.2 | 2.0 |
| | FISH AND WILDLIFE | 8 | 0.0 | 52.9 | 0.0 |
| | OTHER | 0 | 22 | 648 | 556 |
| | GRAND TOTALS | 352 | 256 | 14,244 | 9,451 |

**Table A-9. Little Missouri subbasin permits and applications June 30, 1989 through April 30, 1993**

| DRAINAGE | PURPOSE | NUMBER | TOTAL RATE (cfs) | VOLUME (af) | LAND USED ON (acres) |
|---|---|---|---|---|---|
| BEAVER CREEK | OTHER | 2 | 22.3 | 107.4 | 37.5 |
| | DRAINAGE TOTALS | 2 | 22.3 | 107.4 | 37.5 |
| BOXELDER CREEK | STOCK | 25 | 0.0 | 111.7 | 0.0 |
| | DRAINAGE TOTALS | 25 | 0.0 | 111.8 | 0.0 |
| LITTLE MISSOURI RIVER | STOCK | 33 | 0.0 | 195.5 | 0.0 |
| | OTHER | 1 | 35.6 | 875.0 | 350.0 |
| | DRAINAGE TOTALS | 34 | 35.6 | 1,070.5 | 350.0 |
| SUBBASIN TOTALS | STOCK | 58 | 0.0 | 307.3 | 0.0 |
| | OTHER | 3 | 58.0 | 982.4 | 387.5 |
| | GRAND TOTALS | 61 | 58 | 1,290 | 388 |

# APPENDIX B

## SUMMARY OF WATER RESERVATIONS GRANTED BY THE BOARD IN THE MISSOURI RIVER BASIN ABOVE FORT PECK DAM

## Reservations granted to municipalities (1st priority)

| Municipality | Source | ——-Amount——-<br>cfs | <br>acre-feet/ year |
|---|---|---|---|
| Belgrade | Wells (2) | 3.56 | 645 |
| Bozeman | Sourdough (Bozeman) Creek | 47.3 | 2,857 |
| Chester | Marias River | 0.93 | 340 |
| Choteau | Wells(4) | Application withdrawn | |
| Conrad | Lake Frances (inactive pool) | Application denied | |
| Cut Bank | Cut Bank Creek | 1.42 | 400 |
| Dillon | Well | Application denied | |
| East Helena | Wells | 0.93 | 258 |
| Fairfield | Wells (2) | 0.34 | 100 |
| Fort Benton | | | |
| Municipal | Missouri River | 0.76 | 89 |
| Parks Irrigation | Missouri River | 0.67 | 35 |
| Great Falls | | | |
| Municipal | Missouri River | 11.5 | 6,022 |
| Parks Irrigation | Missouri River | 4.45 | 233.5 |
| Parks Irrigation | Sun River | 4.45 | 233.5 |
| Helena | Wells (6-8) | 16.4 | 7,071 |
| Lewistown | Big Spring Creek | 1.1 | 1,247 |
| Power | Muddy Creek | Application denied | |
| Shelby | Wells | 0.23 | 161 |
| Three Forks | Well | 0.45 | 81 |
| West Yellowstone | Whiskey Spring | 2.65 | 1,922 |
| Winifred | Well | 0.23 | 50 |

**Instream flow reservations granted to DHES (2nd priority)**

| Stream | Amount cfs | Amount acre-feet/year |
|---|---|---|
| Missouri River at Toston | 2,596 | 1,879,504 |
| Missouri River at Ulm | 3,204 | 2,319,696 |
| Missouri River at Virgelle | 4,390 | 3,178,360 |
| Missouri River at Landusky | 4,815 | 3,486,060 |

## Instream flow reservations granted to DFWP (3rd priority)

### HEADWATERS SUBBASIN

BIG HOLE RIVER DRAINAGE

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| American Creek | Headwaters to mouth | Jan 1 - Dec 31 | 2.8 |
| Bear Creek | Headwaters to mouth | Jan 1 - Dec 31 | 2.8 |
| Big Hole River #1 | Warm Springs Creek to Pintlar Creek | Jan 1 - Dec 31 | 160 |
| Big Hole River #2 | Pintlar Creek to the old Divide Dam | Jan 1 - Dec 31 | 800 |
| Big Hole River #3 | Old Divide Dam to mouth | Jan 1 - Dec 31 | 573 |
| Big Lake Creek | Twin Lakes outlet to mouth | Jan 1 - Dec 31 | 4.7 |
| Birch Creek | Mule Creek to mouth | Jan 1 - Dec 31 | 10 |
| Bryant Creek | Headwaters to mouth | Jan 1 - Dec 31 | 1.4 |
| California Creek | Headwaters to mouth | Jan 1 - Dec 31 | 10 |
| Camp Creek | Headwaters to mouth | Jan 1 - Dec 31 | 5 |
| Canyon Creek | Canyon Lake to mouth | Jan 1 - Dec 31 | 5 |
| Corral Creek | Headwaters to mouth | Jan 1 - Dec 31 | 1 |
| Deep Creek | Sevenmile and Tenmile to mouth | Jan 1 - Dec 31 | 18 |
| Delano Creek | Headwaters to mouth | Jan 1 - Dec 31 | 0.3 |
| Divide Creek | North and East forks to mouth | Jan 1 - Dec 31 | 3 |
| Fishtrap Creek | West and Middle forks to mouth | Jan 1 - Dec 31 | 10 |
| Francis Creek | Sand Creek to mouth | Jan 1 - Dec 31 | 4 |
| French Creek | Headwaters to mouth | Jan 1 - Dec 31 | 3 |
| Governor Creek | Headwaters to mouth | Jan 1 - Dec 31 | 4 |
| Jacobsen Creek | Tahepia Lake to mouth | Jan 1 - Dec 31 | 14 |
| Jerry Creek | Headwaters to mouth | Jan 1 - Dec 31 | 7 |
| Johnson Creek | Schultz Creek to Forest Service boundary | Jan 1 - Dec 31 | 13 |
| Joseph Creek | Anderson Creek to mouth | Jan 1 - Dec 31 | 5 |
| LaMarche Creek | West and Middle forks to mouth | Jan 1 - Dec 31 | 11 |
| Miner Creek | Upper Miner Lakes to mouth | Jan 1 - Dec 31 | 9 |
| Moose Creek | Headwaters to mouth | Jan 1 - Dec 31 | 9 |
| Mussigbrod Creek | Hell Roaring Creek to uppermost existing diversion point in NWSENW Section 9 T1S R16W | Jan 1 - Dec 31 | 10 |
| NF Big Hole River | Ruby and Trail creeks to mouth | Jan 1 - Dec 31 | 30 |
| Oregon Creek | Headwaters to mouth | Jan 1 - Dec 31 | 0.3 |
| Pattengail Creek | Sand Lake to mouth | Jan 1 - Dec 31 | 12 |
| Pintlar Creek | Oreamnos Lake to mouth | Jan 1 - Dec 31 | 10 |
| Rock Creek | Beaverhead National Forest boundary to mouth | Jan 1 - Dec 31 | 5 |
| Ruby Creek | Pioneer and WF Ruby creeks to mouth | Jan 1 - Dec 31 | 4 |
| Sevenmile Creek | Headwaters to mouth | Jan 1 - Dec 31 | 1.8 |
| Seymour Creek | Upper Seymour Lake to mouth | Jan 1 - Dec 31 | 13 |
| Sixmile Creek | Headwaters to mouth | Jan 1 - Dec 31 | 1.6 |
| SF Big Hole River | Skinner Lake to mouth | Jan 1 - Dec 31 | 22 |
| Steel Creek | Headwaters to mouth | Jan 1 - Dec 31 | 6 |
| Sullivan Creek | Headwaters to mouth | Jan 1 - Dec 31 | 4 |
| Swamp Creek | Yank Swamp to mouth | Jan 1 - Dec 31 | 8 |
| Tenmile Creek | Tenmile Lakes to mouth | Jan 1 - Dec 31 | 3.8 |
| Trail Creek | Headwaters to mouth | Jan 1 - Dec 31 | 6 |
| Trapper Creek | Trapper Lake to mouth | Jan 1 - Dec 31 | 1.8 |
| Twelvemile Creek | Headwaters to mouth | Jan 1 - Dec 31 | 1.2 |
| Warm Springs Creek | West and East forks to mouth | Jan 1 - Dec 31 | 5 |
| Willow Creek | Tendoy Lake to mouth | Jan 1 - Dec 31 | 16 |
| Wise River | Mono and Jacobson creeks to mouth | Jan 1 - Dec 31 | 20 |
| Wyman Creek | Headwaters to mouth | Jan 1 - Dec 31 | 7 |

## DFWP (cont.)

### GALLATIN RIVER DRAINAGE

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Baker Creek | Heeb Lane Bridge to mouth | Jan 1 - Dec 31 | 14 |
| Ben Hart Creek | Headwaters to mouth | Jan 1 - Dec 31 | 29 |
| Big Bear Creek | Headwaters to mouth | Jan 1 - Dec 31 | 2 |
| Bridger Creek | Headwaters to mouth | Jan 1 - Dec 31 | 14 |
| Cache Creek | Headwaters to mouth | Jan 1 - Dec 31 | 2.6 |
| EF Hyalite Creek | Heather Lake to Hyalite Reservoir | Jan 1 - Dec 31 | 7 |
| East Gallatin River #1 | Rocky and Sourdough cks to Bozeman STP outlet | Jan 1 - Dec 31 | 42.4 |
| East Gallatin River #2 | Bozeman STP outlet to Thompson Spring Creek | Jan 1 - Dec 31 | 90 |
| East Gallatin River #3 | Thompson Spring Creek to mouth | Jan 1 - Dec 31 | 170 |
| Gallatin River #1 | Yellowstone NP boundary to WF Gallatin River | Jan 1 - Dec 31 | 170 |
| Gallatin River #2 | WF Gallatin River to East Gallatin River | Jan 1 - Dec 31 | 400 |
| Gallatin River #3 | East Gallatin River to mouth | Jan 1 - Dec 31 | 533.5 |
| Hell Roaring Creek | NF Hell Roaring Creek to mouth | Jan 1 - Dec 31 | 16 |
| Hyalite (Middle) Creek #1 | Middle Creek Dam to Middle Creek Ditch intake | Jan 1 - Dec 31 | 28 |
| Hyalite (Middle) Creek #2 | I-90 bridge near Belgrade to mouth | Jan 1 - Dec 31 | 16 |
| MF of the WF Gallatin R. | Headwaters to NF of the WF Gallatin River | Jan 1 - Dec 31 | 3 |
| Porcupine Creek | NF Porcupine Creek to mouth | Jan 1 - Dec 31 | 4.5 |
| Reese Creek | Bill Smith Creek to mouth | Jan 1 - Dec 31 | 5 |
| Rocky Creek | Jackson Creek to Sourdough Creek | Jan 1 - Dec 31 | 18 |
| Sourdough (Bozeman) Ck. | Mystic Reservoir to mouth | Jan 1 - Dec 31 | 11 |
| South Cottonwood Creek | Jim Creek to Hart Ditch headgate | Jan 1 - Dec 31 | 14 |
| SF Spanish Creek | Falls Creek to mouth | Jan 1 - Dec 31 | 15 |
| SF of the WF Gallatin R. | Headwaters to mouth | Jan 1 - Dec 31 | 5 |
| Spanish Creek | North and South forks to mouth | Jan 1 - Dec 31 | 70 |
| Squaw Creek | Headwaters to mouth | Jan 1 - Dec 31 | 12 |
| Taylor Fork | Tumbledown Creek to mouth | Jan 1 - Dec 31 | 36 |
| Thompson Spring Creek | County road crossing in T1N R5E Sec 30 to mouth | Jan 1 - Dec 31 | 29 |
| WF Gallatin River | Middle and North forks to mouth | Jan 1 - Dec 31 | 26 |
| WF Hyalite Creek | Hyalite Lake to Hyalite Reservoir | Jan 1 - Dec 31 | 12 |

### JEFFERSON AND BOULDER RIVER DRAINAGES

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Boulder River #1 | West and South forks to High Ore Creek | Jan 1 - Dec 31 | 20 |
| Boulder River #2 | High Ore Creek to Cold Spring | Jan 1 - Dec 31 | 8 |
| Boulder River #3 | Cold Spring to mouth | Jan 1 - Dec 31 | 47 |
| Halfway Creek | Headwaters to canyon | Jan 1 - Dec 31 | 1.9 |
| Hells Canyon Creek | Headwaters to mouth | Jan 1 - Dec 31 | 3.6 |
| Jefferson River | Headwaters to Madison River | Jan 1 - Dec 31 | 1,095.5 |
| Little Boulder River | Moose Creek to mouth | Jan 1 - Dec 31 | 7 |
| North Willow Creek | Hollow Top Lake to mouth | Jan 1 - Dec 31 | 7 |
| South Boulder River | Curly Creek to mouth | Jan 1 - Dec 31 | 12 |
| South Willow Creek | Granite Lake to mouth | Jan 1 - Dec 31 | 14 |
| Whitetail Creek | Whitetail Reservoir to mouth | Jan 1 - Dec 31 | 3 |
| Willow Creek | North and South Willow creeks to mouth | Jan 1 - Dec 31 | 14 |
| Willow Spring Creek | Headwaters to mouth | Jan 1 - Dec 31 | 9.2 |

## DFWP (cont.)

MADISON RIVER DRAINAGE

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Antelope Creek | Headwaters to mouth | Jan 1 - Dec 31 | 14 |
| Beaver Creek | Wyethia Creek to Earthquake Lake | Jan 1 - Dec 31 | 22 |
| Black Sand Spring Creek | Black Sand Spring to SF Madison River | Jan 1 - Dec 31 | 18.7 |
| Blaine Spring Creek | Ennis National Fish Hatchery to mouth | Jan 1 - Dec 31 | 23 |
| Cabin Creek | Gully Creek to Madison River | Jan 1 - Dec 31 | 22 |
| Cherry Creek | Headwaters to mouth | Jan 1 - Dec 31 | 15 |
| Cougar Creek | Yellowstone NP boundary to mouth | Jan 1 - Dec 31 | 24 |
| Duck Creek | Yellowstone NP boundary to Hebgen Reservoir | Jan 1 - Dec 31 | 23 |
| Elk River | Headwaters to mouth | Jan 1 - Dec 31 | 28 |
| Grayling Creek | Yellowstone NP boundary to Hebgen Reservoir | Jan 1 - Dec 31 | 34 |
| Hot Springs Creek | North and Middle forks to mouth | Jan 1 - Dec 31 | 5.5 |
| Indian Creek | Raw Liver Creek to mouth | Jan 1 - Dec 31 | 48 |
| Jack Creek | Lone Creek to mouth | Jan 1 - Dec 31 | 24 |
| Madison River #1 | Yellowstone NP boundary to Hebgen Reservoir | Jan 1 - Dec 31 | 245 |
| Madison River #2 | Hebgen Dam to West Fork | Jan 1 - Dec 31 | 502.5 |
| Madison River #3 | West Fork to Ennis Reservoir | Jan 1 - Dec 31 | 716 |
| Madison River #4 | Ennis Dam to mouth | Jan 1 - Dec 31 | 825 |
| Moore Creek | Fletcher Creek to mouth | Jan 1 - Dec 31 | 1.4 |
| North Meadow Creek | Headwaters to mouth | Jan 1 - Dec 31 | 18 |
| O'Dell Creek | Headwaters to mouth | Jan 1 - Dec 31 | 98 |
| Red Canyon Creek | Headwaters to Hebgen Reservoir | Jan 1 - Dec 31 | 2.9 |
| Ruby Creek | Beartrap Canyon to mouth | Jan 1 - Dec 31 | 18 |
| SF Madison River | Dry Canyon to Hebgen Reservoir | Jan 1 - Dec 31 | 92 |
| Squaw Creek | North Fork to mouth | Jan 1 - Dec 31 | 14 |
| Standard Creek | Headwaters to mouth | Jan 1 - Dec 31 | 10 |
| Trapper Creek | Headwaters to Hebgen Reservoir | Jan 1 - Dec 31 | 3.2 |
| Watkins Creek | Coffin Creek to Hebgen Reservoir | Jan 1 - Dec 31 | 5.5 |
| WF Madison River | Fox Creek to mouth | Jan 1 - Dec 31 | 42 |

RED ROCK-BEAVERHEAD DRAINAGE

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Bear Creek | Headwaters to BLM boundary | Jan 1 - Dec 31 | 6.5 |
| Beaverhead River #1 | Clark Canyon to East Bench Div Dam at Barretts | Jan 1 - Dec 31 | 200 |
| Beaverhead River #2 | East Bench Diversion Dam at Barretts to mouth | Jan 1 - Dec 31 | 200 |
| Big Sheep Creek | Cabin and Nicholia creeks to mouth | Jan 1 - Dec 31 | 33 |
| Black Canyon Creek | Headwaters to mouth | Jan 1 - Dec 31 | 2.5 |
| Blacktail Deer Creek | MF and WF to uppermost existing diversion point in SENENE Section 29 T8S R8W | Jan 1 - Dec 31 | 27 |
| Bloody Dick Creek | Swift Lake outlet to mouth | Jan 1 - Dec 31 | 20 |
| Browns Canyon Creek | Headwaters to mouth | Jan 1 - Dec 31 | 2.3 |
| Cabin Creek | Headwaters to mouth | Jan 1 - Dec 31 | 0.4 |
| Corral Creek | Headwaters to mouth | Jan 1 - Dec 31 | 6 |
| Deadman Creek | Deadman Lake to mouth | Jan 1 - Dec 31 | 4.5 |
| EF Blacktail Deer Creek | Headwaters to mouth | Jan 1 - Dec 31 | 18 |
| EF Clover Creek | Headwaters to mouth | Jan 1 - Dec 31 | 4.4 |
| EF Dyce Creek | Headwaters to mouth | Jan 1 - Dec 31 | 1.4 |
| Frying Pan Creek | Headwaters to mouth | Jan 1 - Dec 31 | 1.6 |
| Grasshopper Creek | Blue Creek to mouth | Jan 1 - Dec 31 | 25.8 |
| Hell Roaring Creek | Headwaters to mouth | Jan 1 - Dec 31 | 15 |
| Horse Prairie Creek | Headwaters to mouth | Jan 1 - Dec 31 | 20 |
| Indian Creek | Headwaters to mouth | Jan 1 - Dec 31 | 0.2 |
| Jones Creek | Headwaters to Lakeview Road crossing | Jan 1 - Dec 31 | 1.9 |
| Long Creek | Jones Creek to mouth | Jan 1 - Dec 31 | 3.4 |

## DFWP (cont.)

### RED ROCK-BEAVERHEAD DRAINAGE (continued)

| | | | |
|---|---|---|---|
| Medicine Lodge Creek | Bear Canyon to mouth | Jan 1 - Dec 31 | 10 |
| Narrows Creek | Spring in T13S R1E Sec18A to Elk Lake | May 1 - July 15 | 1.2 |
| | | July 16 - Apr 30 | 0.5 |
| Odell Creek | Headwaters to Lower Red Rock Lake | Jan 1 - Dec 31 | 11 |
| Peet Creek | Headwaters to reservoir in T14S R4W Sec34A | Jan 1 - Dec 31 | 0.9 |
| Poindexter Slough | Springs & canal T8S R9W Sec3,SW to Beaverhead | Jan 1 - Dec 31 | 57.9 |
| Rape Creek | Headwaters to reservoir in T10S R13W Sec4 | Jan 1 - Dec 31 | 0.4 |
| Red Rock Creek | Headwaters to Upper Red Rock Lake | Jan 1 - Dec 31 | 15 |
| Red Rock River #1 | Dam at Lower Red Rock Lake to Lima Reservoir | Jan 1 - Dec 31 | 55 |
| Red Rock River #2 | Lima Dam to Clark Canyon Reservoir | Jan 1 - Dec 31 | 60 |
| Reservoir Creek | Headwaters to mouth | Jan 1 - Dec 31 | 1.5 |
| Shenon Creek | Headwaters to BLM boundary in T10S R14W Sec25 | Jan 1 - Dec 31 | 0.4 |
| Simpson Creek | Headwaters to mouth | Jan 1 - Dec 31 | 0.7 |
| Tom Creek | Headwaters to Upper Red Rock Lake | Jan 1 - Dec 31 | 1.4 |
| Trapper Creek | Headwaters to mouth | Jan 1 - Dec 31 | 0.7 |
| WF Blacktail Deer Creek | Grays and South forks to mouth | Jan 1 - Dec 31 | 3 |
| WF Dyce Creek | Headwaters to mouth | Jan 1 - Dec 31 | 0.7 |

### RUBY RIVER DRAINAGE

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Coal Creek | Headwaters to mouth | Jan 1 - Dec 31 | 3.6 |
| Cottonwood Creek | Geyser Creek to mouth | Jan 1 - Dec 31 | 4 |
| EF Ruby River | Headwaters to mouth | Jan 1 - Dec 31 | 3 |
| MF Ruby River | Divide Creek to mouth | Jan 1 - Dec 31 | 5 |
| Mill Creek | Outlet of Branham Lake to mouth | Jan 1 - Dec 31 | 10 |
| NF Greenhorn Creek | Headwaters to mouth | Jan 1 - Dec 31 | 3.5 |
| Ruby River #1 | East, Middle, and West forks to Ruby Reservoir | Jan 1 - Dec 31 | 90 |
| Ruby River #2 | Ruby Dam to mouth | Jan 1 - Dec 31 | 40 |
| Warm Springs Creek | Romy Lake outlet to mouth | Jan 1 - Dec 31 | 48.5 |
| WF Ruby River | Headwaters to mouth | Jan 1 - Dec 31 | 3.0 |
| Wisconsin Creek | Crystal Lake outlet to mouth | Jan 1 - Dec 31 | 6 |

## UPPER MISSOURI SUBBASIN

### UPPER MISSOURI RIVER AND TRIBUTARIES

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Avalanche Creek | Cooney Gulch to Canyon Ferry Reservoir | Jan 1 - Dec 31 | 5 |
| Beaver Creek | Headwaters in Elkhorn Mts to Canyon Ferry Reservoir | Jan 1 - Dec 31 | 2.8 |
| Beaver Creek | Headwaters in Big Belt Mts to mouth | Jan 1 - Dec 31 | 10.0 |
| Canyon Creek | Headwaters to mouth | Jan 1 - Dec 31 | 10.0 |
| Confederate Gulch | Debauch Gulch to mouth | Jan 1 - Dec 31 | 5 |
| Cottonwood Creek | Headwaters to mouth | Jan 1 - Dec 31 | 1.0 |
| Crow Creek | Tizer and Wilson Creeks to Williams Ditch intake | Jan 1 - Dec 31 | 11 |
| Deep Creek | Castle Fork to Missouri River | Jan 1 - Dec 31 | 9 |
| Dry Creek | Headwaters to Broadwater Missouri Canal | Jan 1 - Dec 31 | 1.8 |
| Duck Creek | Headwaters to Canyon Ferry Res. | Jan 1 - Dec 31 | 8 |
| Little Prickly Pear Ck. #1 | Canyon Creek to Clark Creek | Jan 1 - Dec 31 | 22 |
| Little Prickly Pear Ck. #2 | Clark Creek to mouth | Jan 1 - Dec 31 | 70 |
| Lyons Creek | Headwaters to mouth | Jan 1 - Dec 31 | 10.0 |
| McGuire Creek | Headwaters to mouth | May 1 - Nov 30 | 8.3 |
| | | Dec 1 - Apr 30 | 4.7 |
| Missouri River #1 | Jefferson and Madison rivers to Canyon Ferry Res. | Jan 1 - Dec 31 | 2,400 |
| Missouri River #2 | Hauser Dam to Holter Reservoir | Jan 1 - Dec 31 | 2,881 |

## DFWP (cont.)

UPPER MISSOURI RIVER AND TRIBUTARIES (continued)

| | | | |
|---|---|---|---|
| Missouri River #3 | Holter Dam to Great Falls | Jan 1 - Dec 31 | 3,327 |
| Prickly Pear Creek #1 | Rabbit Gulch to Hwy 12 bridge in East Helena | Jan 1 - Dec 31 | 22 |
| Prickly Pear Creek #2 | Hwy 12 bridge in East Helena to Lake Helena | Jan 1 - Dec 31 | 30 |
| Sevenmile Creek | Greenhorn Creek and Skelly Gulch to mouth | Jan 1 - Dec 31 | 1.0 |
| Sheep Creek | Headwaters to mouth | Jan 1 - Dec 31 | 35 |
| Sheep Creek | Headwaters of South Fork to mouth | Jan 1 - Dec 31 | 22 |
| Silver Creek | Helena Valley Irrigation Canal to mouth | May 1 - Nov 30 | 13.0 |
| | | Dec 1 - Apr 30 | 5.4 |
| Sixteenmile Creek | Billy Creek to mouth | Jan 1 - Dec 31 | 20 |
| Spokane Creek | Helena Valley Irr. Canal to mouth | May 1 - Nov 30 | 4.0 |
| | | Dec 1 - Apr 30 | 3.0 |
| Stickney Creek | North and South forks to mouth | Apr 1 - Apr 30 | 7 |
| | | May 1 - May 31 | 34 |
| | | June 1 - June 30 | 35 |
| | | July 1 - July 31 | 7 |
| Tenmile Creek | Headwaters to mouth | Jan 1 - Dec 31 | 12.0 |
| Trout Creek | Springs near Vigilante Campground to mouth | Jan 1 - Dec 31 | 15.0 |
| Virginia Creek | Headwaters to mouth | Jan 1 - Dec 31 | 6.0 |
| Wegner Creek | Headwaters to mouth | Apr 1 - Apr 30 | 8 |
| | | May 1 - May 31 | 41 |
| | | June 1 - June 30 | 38 |
| | | July 1 - July 31 | 8 |
| Willow Creek | Headwaters to mouth | Jan 1 - Dec 31 | 3.5 |
| Wolf Creek | Headwaters to mouth | Jan 1 - Dec 31 | 7.0 |

DEARBORN RIVER DRAINAGE

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Dearborn River | Headwaters to mouth | Jan 1 - Dec 31 | 110 |
| Flat Creek | Headwaters to mouth | Jan 1 - Dec 31 | 7.5 |
| MF Dearborn River | Headwaters to mouth | Jan 1 - Dec 31 | 9.5 |
| SF Dearborn River | Headwaters to mouth | Jan 1 - Dec 31 | 11.5 |

SMITH RIVER DRAINAGE

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Big Birch Creek | Headwaters to mouth | Jan 1 - Dec 31 | 11 |
| Eagle Creek | Headwaters to mouth | Jan 1 - Dec 31 | 2.5 |
| Hound Creek | EF Hound Creek and Middle Creek to mouth | Jan 1 - Dec 31 | 35 |
| Newlan Creek | Headwaters to mouth | Jan 1 - Dec 31 | 3.8 |
| NF Deep Creek | Headwaters to rock cascades | Jan 1 - Dec 31 | 1.0 |
| NF Smith River | Headwaters to mouth | Jan 1 - Dec 31 | 9 |
| Rock Creek | Headwaters to mouth | Jan 1 - Dec 31 | 11 |
| Smith River #1 | North and South Forks Sheep Creek | Jan 1 - Dec 31 | 78.5 |
| Smith River #2 | Sheep Creek to Hound Creek | Jan 1 - Dec 31 | 150 |
| Smith River #3 | Hound Creek to mouth | Jan 1 - Dec 31 | 80 |
| SF Smith River | Headwaters to mouth | Jan 1 - Dec 31 | 7 |
| Tenderfoot Creek | Headwaters to mouth | Jan 1 - Dec 31 | 15 |

## DFWP (cont.)

### SUN RIVER DRAINAGE

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Elk Creek | Headwaters to mouth | Jan 1 - Dec 31 | 16 |
| Ford Creek | Headwaters to mouth | Jan 1 - Dec 31 | 12 |
| NF Willow Creek | Headwaters to mouth | Jan 1 - Dec 31 | 3.0 |
| Sun River #1 | Diversion Dam to Elk Creek | Jan 1 - Dec 31 | 100 |
| Sun River #2 | Elk Creek to mouth | Jan 1 - Dec 31 | 130 |
| Willow Creek | Headwaters to mouth | Jan 1 - Dec 31 | 3 |

### BELT CREEK DRAINAGE

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Belt Creek #1 | Headwaters to Big Otter Creek | Jan 1 - Dec 31 | 90 |
| Belt Creek #2 | Big Otter Creek to Missouri River | Jan 1 - Dec 31 | 35 |
| Big Otter Creek | Whiskey Spring Coulee to Belt Creek | Jan 1 - Dec 31 | 5 |
| Dry Fork Belt Creek | Galena and Oti Park Creek to Belt Creek | Jan 1 - Dec 31 | 7 |
| Logging Creek | Headwaters to Belt Creek | Jan 1 - Dec 31 | 6 |
| Pilgrim Creek | Headwaters to Belt Creek | Jan 1 - Dec 31 | 8 |
| Tillinghast Creek | Headwaters to Belt Creek | Jan 1 - Dec 31 | 5.5 |

## MIDDLE MISSOURI SUBBASIN

### MIDDLE MISSOURI RIVER AND TRIBUTARIES

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Cow Creek | NF and SF to County bridge | Jan 1 - Dec 31 | 4.5 |
| Highwood Creek | Headwaters to Hwy 228 Bridge at Highwood | Jan 1 - Dec 31 | 10 |
| Missouri River #4 | Great Falls to Maris River | Jan 1 - Dec 31 | 3,876 |
| Missouri River #5 | Marias River to Judith River | Jan 1 - Dec 31 | 4,280 |
| Missouri River #6 | Judith River to upper end of Fort Peck Reservoir | Jan 1 - Dec 31 | 4,652 |
| Shonkin Creek | Forest boundary to town of Shonkin | Jan 1 - Dec 31 | 7 |

### FORT PECK RESERVOIR TRIBUTARIES

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Big Dry Creek | Hwy 200 bridge to mouth | Mar 15 - Mar 31 | 300 |
| | | Apr 1 - Apr 30 | 100 |
| | | May 1 - May 31 | 35 |
| | | June 1 - Oct 31 | 5.5 |
| Little Dry Creek | Whiteside ranch house to Big Dry Creek | Mar 15 - Mar 31 | 110 |
| | | Apr 1 - Apr 30 | 42 |
| | | May 1 - May 31 | 17 |
| | | June 1 - Oct 31 | 3.5 |

## DFWP (cont.)

### JUDITH RIVER DRAINAGE

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Beaver Creek | West Fork to Cottonwood Creek | Jan 1 - Dec 31 | 5 |
| Big Spring Creek #1 | Fish hatchery to Cottonwood Creek | Jan 1 - Dec 31 | 53.5 |
| Big Spring Creek #2 | Cottonwood Creek to mouth | Jan 1 - Dec 31 | 100 |
| Cottonwood Creek | Spring Branch of Cottonwood Ck. to Big Spring Ck. | Jan 1 - Dec 31 | 4.5 |
| East Fork Big Spring Ck. | Headwaters to Big Spring Creek | Jan 1 - Dec 31 | 7.5 |
| Judith River #1 | SF and MF to Big Spring Creek | Jan 1 - Dec 31 | 25 |
| Judith River #2 | Big Spring Creek to Missouri River | Jan 1 - Dec 31 | 160 |
| Lost Fork Judith River | SF and WF to MF Judith River | Jan 1 - Dec 31 | 14 |
| Middle Fork Judith River | Headwaters to South Fork | Jan 1 - Dec 31 | 22 |
| South Fork Judith River | Headwaters to Middle Fork | Jan 1 - Dec 31 | 3.5 |
| Warm Spring Creek | Springs to Judith River | Jan 1 - Dec 31 | 110 |
| Yogo Creek | Headwaters to MF Judith River | Jan 1 - Dec 31 | 3 |

### MUSSELSHELL RIVER DRAINAGE

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Alabaugh Creek | Headwaters to mouth | Jan 1 - Dec 31 | 12 |
| American Fork Creek | South Fork to mouth | Jan 1 - Dec 31 | 5.5 |
| Big Elk Creek | Origin at Lebo Fork to mouth | Jan 1 - Dec 31 | 9.5 |
| Careless Creek | Headwaters to Roberts Creek | Jan 1 - Dec 31 | 2 |
| Checkerboard Creek | East and West Forks to mouth | Jan 1 - Dec 31 | 6 |
| Collar Gulch Creek | Headwaters to mouth | Jan 1 - Dec 31 | 0.6 |
| Cottonwood Creek | WF, MF, and Loco Creek to mouth | Jan 1 - Dec 31 | 16 |
| Flatwillow Creek | NF and SF to Petrolia Reservoir | Jan 1 - Dec 31 | 15 |
| Musselshell River #1 | NF and SF to Deadmans Basin Div | Jan 1 - Dec 31 | 80 |
| Musselshell River #2 | Deadmans Basin Div to Musselshell Div | Jan 1 - Dec 31 | 80 |
| Musselshell River #3 | Musselshell Diversion Dam at town of Musselshell to mouth | Jan 1 - Dec 31 | 70 |
| NF Musselshell #1 | Headwaters to Bair Reservoir | Jan 1 - Dec 31 | 3 |
| NF Musselshell #2 | Bair Reservoir to SF Musselshell R. | Jan 1 - Dec 31 | 16 |
| SF Musselshell | Headwaters to North Fork | Jan 1 - Dec 31 | 30 |
| Spring Creek | Headwaters to mouth | Jan 1 - Dec 31 | 8 |
| Swimming Woman Ck. | Headwaters to Cty road crossing 8 linear miles upstream from mouth | Jan 1 - Dec 31 | 2.5 |

## MARIAS/TETON SUBBASIN

### MARIAS RIVER DRAINAGE

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Badger Creek | N and S Badger creeks to Forest/ Blackfeet Reservation Boundary | Jan 1 - Dec 31 | 60 |
| Birch Creek | Swift Reservoir to Hwy 358 | Jan 1 - Dec 31 | 64 |
| Cut Bank Creek | Blackfeet Reservation boundary to mouth | Jan 1 - Dec 31 | 75 |
| Dupuyer Creek | Headwaters to mouth | Jan 1 - Dec 31 | 12 |
| Marias River #1 | Two Medicine River and Cut Bank Creek to head of Tiber Reservoir | Jan 1 - Dec 31 | 200 |
| Marias River #2 | Tiber Dam to Circle Bridge (Hwy 223) | Jan 1 - Dec 31 | 419.5 |
| Marias River #3 | Circle Bridge (Hwy 223) to mouth | Jan 1 - Dec 31 | 488.5 |
| North Badger Creek | Headwaters to mouth | Jan 1 - Dec 31 | 14 |
| NF Dupuyer Creek | Headwaters to mouth | Jan 1 - Dec 31 | 12 |
| South Badger Creek | Headwaters to mouth | Jan 1 - Dec 31 | 40 |
| SF Dupuyer Creek | Headwaters to mouth | Jan 1 - Dec 31 | 6 |
| SF Two Medicine River | Headwaters to Forest/Blackfeet Reservation Boundary | Jan 1 - Dec 31 | 16 |

## DFWP (cont.)

TETON RIVER DRAINAGE

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (cfs) |
|---|---|---|---|
| Deep Creek | Headwaters to mouth | Jan 1 - Dec 31 | 18 |
| McDonald Creek | Headwaters to mouth | Jan 1 - Dec 31 | 10 |
| NF Deep Creek | Headwaters to mouth | Jan 1 - Dec 31 | 7.2 |
| SF Deep Creek | Headwaters to mouth | Jan 1 - Dec 31 | 6.9 |
| Spring Creek | Headwaters to mouth | Jan 1 - Dec 31 | 4.5 |
| Teton River | Headwaters to discharge from Priest Butte Lake | Jan 1 - Dec 31 | 35 |

**LAKES AND SWAMPS**

| STREAM | REACH DESCRIPTION | DATES GRANTED | AMOUNT ALLOWED (af/yr) |
|---|---|---|---|
| Bean Lake | Sec. 18C and 19B, T18N, R6W, Sec. 13D and 24A, T18N, R7W | Jan 1 - Dec 31 | 2,649 |
| Antelope Butte Swamp | North 1/2 Sec. 28, T26N, R8W | Jan 1 - Dec 31 | 460 |

### Instream flow reservations granted to the Bureau of Land Management (4th priority)

| STREAM | LOCATION | STREAM MILES WITHIN PUBLIC LANDS | YEAR-ROUND AMOUNT (CFS) | PEAK DISCHARGE AMOUNT (CFS) |
|---|---|---|---|---|
| Deep Creek | T2N-R12W-S20 | .9 | 18 | 500 |
| Bear Creek | T2N-R12W-S34 | 1.1 | 2.5 | 50 |
| Canyon Creek | T2S-R9W-S6 | .9 | 5.0 | 110 |
| Moose Creek | T2S-R9W-S13&23<br>T1S-R8W-S7,8,9&18 | 5.5 | 8 | 70 |
| Camp Creek | T2S-R8W-S2,9, 10,11,17,19&20 | 6.5 | 5 | 50 |
| Willow Creek | T4S-R9W-S31&32 | 1.9 | 12 | 130 |
| East Fork Dyce Creek | T6S-R12W-S14, 23,26&35 | 3.75 | 1.4 | 9 |
| West Fork Dyce Creek | T6S-R12W-S14, 22,23&26 | 3.8 | .7 | 5 |
| Bloody Dick Ck. | T9S-R15W-S23 | 1 | 20 | 270 |
| Medicine Lodge Creek | T12S-R12W-S13<br>T13S-R12W-S2&26 | 1 | 9 | 50 |
| Rape Creek | T10S-R13W-S21&28 | 1 | .4 | 5 |
| Shenon Creek | T10S-R13W-S29,30, 32&33; T10S-R14W-S25 | 3.5 | .4 | 13 |
| Black Canyon Creek | T11S-R14W-S19,20, 21 | 2.8 | 2.5 | 35 |
| Bear Creek (Horse Prarie Creek Drainage) | T10S-R15W-S34 | 1.3 | 1 | 50 |
| Trapper Creek | T10S-R15W-S34 | 1.3 | .7 | 10 |
| Frying Pan Ck. | T10S-R25W-S22,27&28 | 1 | 1.5 | 35 |

| STREAM | LOCATION | STREAM MILES WITHIN PUBLIC LANDS | YEAR-ROUND AMOUNT (CFS) | PEAK DISCHARGE AMOUNT (CFS) |
|---|---|---|---|---|
| Cabin Creek | T14S-R12W-S1&12 | 1.3 | .4 | 4 |
| Indian Creek | T14S-R12W-S24 | 1.3 | .2 | 5 |
| Simpson Creek | T14S-R12W-S25&30 | 0.8 | .7 | 5 |
| Deadman Creek | T15S-R10W-S22 | 2.0 | 4.5 | 50 |
| Big Sheep Ck. | T13S-R9W-S30<br>T13S-R10W-S25,35&36<br>T14S-R10W-S2,10,15,22&34<br>T15S-R10W-S3,10&22 | 10.0 | 32.5 | 300 |
| North Fork Greenhorn Creek | T8-R4W-S13&24 | 1.3 | 3.5 | 35 |
| Jones Creek | T14S-R3W-S33 | 1.1 | 1.9 | 20 |
| Peet Creek | T15S-R4W-S3&10<br>T14S-R4W-S34 | 2.25 | .9 | 30 |
| Corral Creek | T14S-R1E-S22&27 | 1.5 | 2.5 | 20 |
| Odell Creek | T14S-R1W-S31 | 0.8 | 11 | 225 |
| Long Creek | T13S-R4W-S1&2 | 3.9 | 3.4 | 110 |
| Hellroaring Ck. | T14S-R1E-S35&26 | 0.75 | 15 | 250 |
| Tom Creek | T14S-R1E-S32 | 1.2 | 1.4 | 25 |
| East Fork Blacktail Deer Creek | T11S-R5W-S27,34&35 | 3.4 | 18 | 215 |
| West Fork Blacktail Deer Creek | T12S-R6W-S35 | 2.5 | 1 | 25 |

## Reservations granted to conservation districts (5th priority)

| Project Number | Point of Diversion | | | Peak Flow (cfs) | Annual Diversion (af) | Water Source | Project Acres |
|---|---|---|---|---|---|---|---|
| | TWN | RGE | SEC | | | | |
| **Big Sandy** - Application denied | | | | | | | |
| **Broadwater** | | | | | | | |
| BR-34 | T6N | R2E | 33 | 3.76 | 497 | Missouri River | 250 |
| BR-38 | T5N | R2E | 22 | 0.63 | 109 | Well (Warm Springs Creek) | 80 |
| | | | | 4.4 | 606 | | 330 |
| **Cascade County** | | | | | | | |
| CS-42 | T20N | R6E | 24 | 5.94 | 443 | Belt Creek | 124 |
| CS-43 | T20N | R6E | 24 | 3.98 | 599 | Belt Creek | 255 |
| CS-44 | T20N | R7E | 18 | 0.55 | 83 | Belt Creek | 35 |
| CS-61 | T19N | R2E | 15 | 1.15 | 163 | Smith River | 79 |
| CS-62 | T17N | R2E | 25 | 1.06 | 141 | Hound Creek | 59 |
| CS-63 | T17N | R2E | 25 | 1.83 | 129 | Hound Creek | 42 |
| CS-64 | T17N | R2E | 24 | 0.83 | 100 | Hound Creek | 42 |
| CS-101 | T18N | R1W | 25 | 2.15 | 304 | Missouri River | 148 |
| CS-102 | T17N | R1W | 11 | 1.39 | 186 | Missouri River | 79 |
| CS-111 | T19N | R2E | 20 | 6.58 | 799 | Missouri River | 381 |
| CS-159 | T21N | R7E | 32 | 0.76 | 114 | Belt Creek | 48 |
| CS-171 | T21N | R1W | 35 | 0.50 | 70 | Sun River | 28 |
| CS-241 | T21N | R1E | 26 | 1.48 | 190 | Sun River | 76 |
| CS-251 | T19N | R2E | 26 | 1.65 | 245 | Smith River | 91 |
| CS-252 | T19N | R2E | 15 | 0.57 | 77 | Smith River | 28 |
| CS-271 | T19N | R2E | 23 | 0.93 | 134 | Smith River | 50 |
| CS-331 | T18N | R2E | 26 | 0.41 | 57 | Smith River | 24 |
| CS-351 | T18N | R1W | 35 | 2.73 | 369 | Missouri River | 171 |
| CS-541 | T19N | R2E | 8 | 0.54 | 69 | Missouri River | 30 |
| CSI-11 | T17N | R1W | 20 | 2.23 | 287 | Missouri River | 120 |
| CSI-12 | T17N | R1W | 20 | 0.90 | 110 | Missouri River | 46 |
| CSI-21 | T17N | R1W | 16 | 1.50 | 157 | Missouri River | 66 |
| CSI-22 | T17N | R1W | 11 | 1.19 | 163 | Missouri River | 69 |
| CSI-23 | T17N | R1W | 11 | 1.61 | 144 | Missouri River | 61 |
| CSI-33 | T18N | R1E | 30 | 1.10 | 150 | Missouri River | 62 |
| CSI-34 | T18N | R1E | 18 | 1.17 | 164 | Missouri River | 60 |
| CSI-35 | T18N | R1E | 17 | 1.69 | 253 | Missouri River | 108 |
| CSI-41 | T18N | R3E | 12 | 1.44 | 180 | Missouri River | 66 |
| CSI-51 | T19N | R2E | 19 | 1.78 | 250 | Missouri River | 92 |
| CSI-52 | T19N | R2E | 8 | 4.65 | 700 | Missouri River | 298 |
| CSI-71 | T20N | R2W | 4 | 1.32 | 198 | Sun River | 79 |
| CSI-81 | T21N | R1E | 34 | 0.71 | 96 | Sun River | 38 |
| CSI-82 | T21N | R2E | 31 | 1.03 | 137 | Sun River | 55 |
| CSI-83 | T21N | R2E | 30 | 0.49 | 99 | Sun River | 39 |
| CSI-91 | T21N | R2E | 34 | 0.98 | 129 | Sun River | 47 |
| CSI-92 | T20N | R3E | 6 | 0.50 | 72 | Sun River | 26 |
| CSI-101 | T19N | R2E | 4 | 1.57 | 223 | Missouri River | 108 |
| CSI-102 | T19N | R2E | 9 | 1.28 | 171 | Smith River | 72 |
| CSI-103 | T19N | R2E | 11 | 3.71 | 557 | Missouri River | 237 |
| CSI-111 | T18N | R2E | 2 | 6.32 | 843 | Smith River | 387 |
| | | | | 72.2 | 9,355 | | 3,926 |
| **Chouteau County** | | | | | | | |
| CH-21 | T25N | R1E | 31 | 2.64 | 406 | Missouri River | 175 |
| CH-201 | T22N | R9E | 35 | 0.54 | 77 | Shonkin Creek | 29 |
| CH-211 | T23N | R7E | 7 | 2.94 | 382 | Missouri River | 142 |
| CH-541 | T22N | R6E | 22 | 0.21 | 37 | Highwood Creek | 13 |
| CH-551 | T21N | R7E | 12 | 0.64 | 86 | Spring, Big Sag Coulee | 32 |
| CHI-10 | T25N | R10E | 20 | 2.36 | 314 | Missouri River | 116 |
| CHI-21 | T25N | R10E | 8 | 5.29 | 752 | Missouri River | 280 |
| CHI-22 | T25N | R10E | 2 | 3.06 | 389 | Missouri River | 144 |
| CHI-30 | T26N | R11E | 10 | 4.19 | 643 | Missouri River | 279 |
| CHI-40 | T26N | R12E | 5 | 1.89 | 290 | Missouri River | 126 |
| CHI-51 | T25N | R9E | 11 | 1.63 | 244 | Marias River | 98 |
| CHI-52 | T26N | R9E | 32 | 3.33 | 255 | Marias River | 73 |
| CHI-53 | T25N | R9E | 10 | 1.88 | 289 | Marias River | 125 |
| CHI-61 | T25N | R7E | 33 | 1.72 | 247 | Teton River | 107 |
| CHS-3 | T23N | R7E | 8 | 127.62 | 19,654 | Missouri River | 8,475 |
| CHS-5 | T25N | R9E | 36 | 58.81 | 9,058 | Missouri River | 3,905 |
| | | | | 218.8 | 33,123 | | 14,119 |

## Conservation districts (cont.)

| Project Number | Point of Diversion | | | Peak Flow (cfs) | Annual Diversion (af) | Water Source | Project Acres |
|---|---|---|---|---|---|---|---|
| | TWN | RGE | SEC | | | | |
| **Fergus County** | | | | | | | |
| FE-141 | T15N | R18E | 7 | 3.23 | 375 | Wolverine Creek | 222.3 |
| FE-161 | T17N | R17E | 23 | 2.16 | 261 | Lincoln Ditch | 155.1 |
| FE-401 | T14N | R19E | 23 | 0.55 | 64 | East Fork Big Spring Creek | 38.2 |
| FE-431 | T15N | R18E | 21 | 1.06 | 107 | Little Casino Creek | 55.0 |
| FE-671 | T14N | R16E | 19 | 6.43 | 748 | Olsen Creek | 443.4 |
| FE-672 | T14N | R16E | 19 | 3.82 | 444 | UT Olsen Creek | 263.8 |
| FE-673 | T14N | R16E | 30 | 1.13 | 131 | UT Ross Fork Creek | 77.7 |
| FEI-10 | T23N | R16E | 27 | 1.59 | 192 | Missouri River | 114.0 |
| FEI-40 | T18N | R16E | 28 | 13.69 | 1,592 | Warm Springs Creek | 944.3 |
| | | | | 33.7 | 3,914 | | 2,314 |
| **Gallatin** | | | | | | | |
| GA-13 | T2S | R5E | 34 | 1.34 | 106 | Well | 170 |
| GA-14 | T2S | R5E | 25 | 0.63 | 50 | Well | 80 |
| GA-24 | T2S | R5E | 5 | 1.84 | 146 | Well | 234 |
| GA-35 | T2S | R4E | 27 | 0.63 | 71 | Well | 30 |
| GA-44 | T2S | R5E | 3 | 2.20 | 175 | Well | 280 |
| GA-46 | T2S | R5E | 26 | 1.26 | 100 | Well | 160 |
| GA-79 | T1S | R5E | 9 | 4.53 | 509 | Well | 300 |
| GA-81 | T1S | R4E | 3 | 3.47 | 390 | Well | 230 |
| GA-92 | T3N | R5E | 32 | 0.91 | 102 | Well | 60 |
| GA-102 | T1N | R1E | 8 | 2.34 | 250 | Jefferson River | 100 |
| GA-124 | T1N | R5E | 34 | 0.71 | 56 | Well | 90 |
| GA-151 | T1N | R6E | 17 | 0.45 | 51 | Well | 30 |
| | | | | 20.3 | 2,006 | | 1,764 |
| **Glacier County** | | | | | | | |
| GL-11 | T34N | R8W | 32 | 3.72 | 472 | Cut Bank Creek | 277 |
| GL-201 | T30N | R9W | 21 | 3.35 | 220 | Whitetail Creek | 86 |
| GL-221 | T34N | R7W | 22 | 4.37 | 579 | Cut Bank Creek | 340 |
| | | | | 11.4 | 1,271 | | 703 |
| **Hill County** - Application denied | | | | | | | |
| **Jefferson Valley** | | | | | | | |
| JV-17 | T5N | R3W | 29 | 1.87 | 129 | Well | 170 |
| JV-18 | T5N | R3W | 33 | 1.10 | 76 | Well | 100 |
| JV-25 | T1S | R5W | 32 | 0.53 | 59 | Jefferson River | 35 |
| JV-63 | T4N | R2W | 29 | 0.82 | 99 | Well | 50 |
| JV-80 | T3N | R2W | 19 | 0.96 | 67 | Well | 80 |
| JV-81 | T3N | R2W | 31 | 1.31 | 159 | Well | 80 |
| JV-95 | T1N | R5W | 14 | 14.43 | 1,749 | Jefferson River | 440 |
| JV-202 | T1S | R5W | 14 | 88.90 | 12,177 | Jefferson River | 4,950 |
| JV-204 | T2S | R6W | 23 | 7.42 | 703 | Jefferson River | 405 |
| | | | | 117.3 | 15,218 | | 6,310 |
| **Judith Basin** | | | | | | | |
| JB-21 | T15N | R14E | 16 | 0.22 | 27 | Louse Creek | 13 |
| JB-61 | T17N | R8E | 32 | 2.15 | 275 | Little Otter Creek | 154 |
| JB-281 | T17N | R8E | 3 | 0.44 | 28 | Otter Creek | 10 |
| JBS-3 | T17N | R12E | 29 | 3.26 | 401 | Wolf Creek | 225 |
| | | | | 6.0 | 731 | | 402 |
| **Lewis and Clark County** | | | | | | | |
| LC-131 | T20N | R6W | 2 | 1.03 | 151 | Elk Creek | 60 |
| LC-210 | T15N | R3W | 21 | 1.25 | 148 | Missouri River | 62 |
| LCI-20 | T17N | R5W | 25 | 2.51 | 355 | Dearborn River | 173.1 |
| | | | | 4.8 | 654 | | 295 |
| **Liberty County** | | | | | | | |
| LI-161 | T29N | R5E | 3 | 6.77 | 1,043 | Marias River | 450 |
| LI-162 | T29N | R5E | 11 | 4.65 | 690 | Marias River | 298 |
| LI-263 | T29N | R7E | 27 | 2.02 | 269 | Marias River | 134 |
| | | | | 13.5 | 2,002 | | 882 |
| **Lower Musselshell** | | | | | | | |
| LM-20 | T8N | R26E | 18 | 90 | 600 | Groundwater, Musselshell River | — |
| **Meagher County** - Application denied | | | | | | | |

UT - Unnamed tributary

## Conservation districts (cont.)

| Project Number | Point of Diversion | | | Peak Flow (cfs) | Annual Diversion (af) | Water Source | Project Acres |
|---|---|---|---|---|---|---|---|
| | TWN | RGE | SEC | | | | |
| **Pondera County** | | | | | | | |
| PO-171 | T30N | R6W | 34 | 1.81 | 252 | Birch Creek | 130 |
| PO-211 | T28N | R5W | 18 | 0.98 | 130 | Dry Fork Marias River | 58 |
| PO-251 | T28N | R10W | 23 | 0.79 | 94 | Birch Creek | 42 |
| PO-271 | T30N | R4W | 7 | 0.85 | 112 | UT Bullhead Creek | 50 |
| PO-411 | T30N | R4W | 17 | 2.14 | 255 | UT Bullhead Creek | 113 |
| PO-421 | T31N | R6W | 6 | 3.21 | 425 | Two Medicine River | 249 |
| POI-10 | T31N | R7W | 5 | 5.28 | 707 | Two Medicine River | 364.3 |
| | | | | 15.1 | 1,975 | | 1,006 |
| **Teton County** | | | | | | | |
| TE-101 | T26N | R4W | 28 | 1.35 | 192 | Muddy Creek | 92.9 |
| TE-321 | T24N | R5W | 3 | 6.51 | 926 | Well-Teton River | 449.0 |
| TE-571 | T23N | R1W | 27 | 10.52 | 1,593 | Muddy Creek, Sun River | 711.0 |
| TEI-80 | T21N | R6W | 26 | 1.62 | 250 | Sun River | 116.2 |
| TEI-90 | T22N | R8W | 24 | 0.83 | 119 | Sun River | 55.4 |
| TEI-100 | T22N | R8E | 32 | 1.21 | 173 | Sun River | 80.8 |
| | | | | 22.0 | 3,253 | | 1,505 |
| **Toole County** | | | | | | | |
| TO-221 | T31N | R2W | 28 | 1.26 | 153 | Marias River | 66 |
| TO-341 | T31N | R3E | 25 | 3.39 | 488 | Tiber Reservoir | 243 |
| | | | | 4.7 | 641 | | 309 |
| **Valley County** | | | | | | | |
| VAS-1 | T26N | R40E | 26 | 499.11 | 92,000 | Fort Peck Reservoir | 25,020 |

UT - Unnamed tributary

### Rservations granted to U.S. Bureau of Reclamation (6th priority)

--68,000 af per year to be diverted at a maximum rate of 230 cfs from the Missouri River near Virgelle to the Milk River near Havre.

# APPENDIX C

## METHODS USED BY DFWP TO DETERMINE AMOUNTS REQUESTED FOR INSTREAM FLOWS

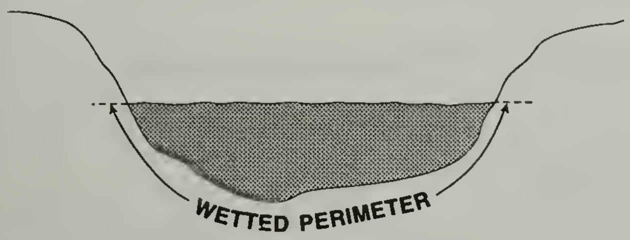
DFWP used several methods to determine the amount of water needed to protect aquatic habitat. A brief description of these methods is presented in the following sections.

## WETTED PERIMETER INFLECTION POINT METHOD

In determining the amount of instream flow necessary to protect habitat in riffle areas of most streams, DFWP used the Wetted Perimeter Inflection Point (WETP) method of calculation (DFWP 1989). This method is based on the assumptions that aquatic organisms contributing the majority of food for gamefish are produced in riffle areas, and that food supply for the fish is a major factor in determining the number of weight of fish a stream can support during the warmer months when fish grow and new fish are recruited into the population. Riffles also are used by many gamefish for spawning and rearing of their young. Wetted perimeter is the linear distance along the bottom and sides of a stream that is in contact with water when the stream is viewed in cross section (see Figure C-1). As flows change, the wetted perimeter changes. If water is maintained in riffles a substantial amount of stream width will extend near enough to streamside vegetation to provide shade and protection to pools and runs where adult fish reside.

The wetted perimeter of riffles usually changes more quickly than that of runs and pools when flows begin to recede. When streamflow is compared to the wetted perimeter, it can be seen that this rate of change is not constant (see Figure C-2). At high flows, the wetted perimeter of a riffle will not change much as flow changes. As flows decrease, the wetted perimeter decreases dramatically with small flow reductions. "Inflection points" occur where the wetted perimeter begins to decline rapidly with additional flow reductions.

**Figure C-1. The wetted perimeter in a channel cross section**

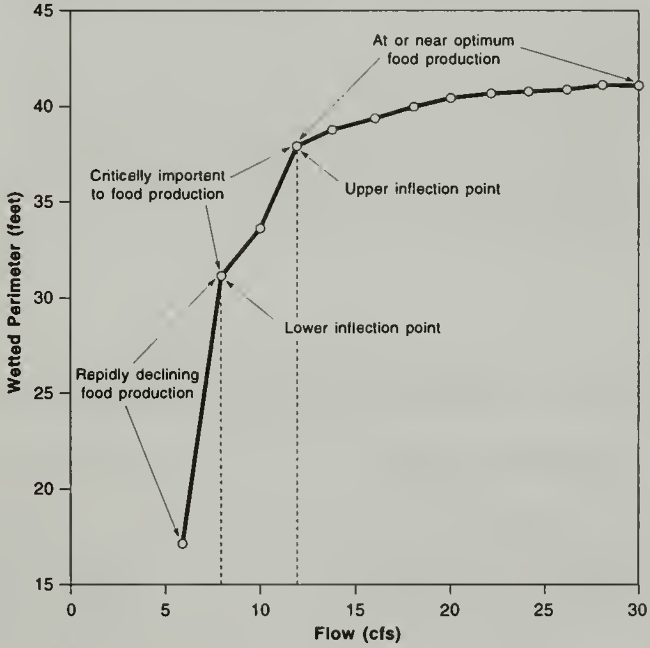


Source: DFWP 1989

At high flows, the channel is full, and, except for floods, the stream has reached its maximum width. As flows are reduced, the wetted perimeter does not change much until the upper inflection point is reached. At the upper inflection point, water beings to drop below the vertical portion of stream banks, and the rate of change in wetted perimeter begins to increase. The point where the stream bottom (roughly horizontal portion of the channel) begins to be dewatered is the lower inflection point. More complex channel shapes may have several inflection points, while some channels may not have clearly defined inflection points. The upper and lower inflection points vary from one stream to another, and within a single stream the upper and lower inflection points will vary from one cross section to another. In determining how much water should be reserved to protect instream values, the applicants surveyed riffle cross sections in the field at several different flows. The wetted perimeter versus flow curves from several riffle cross sections were then averaged when determining inflection points.

According to DFWP, "The Wetted Perimeter Inflection Point Method provides a range of flows (between and including the lower and upper inflection points) from which a single instream flow recommendation is selected. Flows below the lower inflection point are judged undesirable based on their probable impacts on food production, bank cover, and spawning and rearing habitats, while flows at and above the

**Figure B-2. An example of a relationship between wetted perimeter and flow**



Source: DFWP 1989

upper inflection point are considered to provide near optimal conditions for fish. The upper and lower inflection points are believed to bracket those flows needed to maintain high and low levels of aquatic habitat potential "(DFWP 1991).

Within the range of flows between the upper and lower inflection points, DFWP biologists used professional judgment to estimate the instream flow to be requested. They considered the flow needed to sustain particular fish species, quality of habitat, recreational use, water availability, and size and composition of fish populations.

## FIXED PERCENTAGE METHOD

In this method, the WETP was used to find the high inflection point for trout streams in the Bear Paw Mountains. The flow rate corresponding to the high inflection point was then expressed as a percentage of the mean annual flow estimated for that stream. This was done on streams where mean annual flows had been calculated by USGS. The percentages of the mean annual flow at which the high inflection points occurred on these streams were averaged and applied to Reach 1 of Beaver Creek in the Little Rocky Mountains. On Reach 1 of Beaver Creek, this average value was multiplied by the estimated mean annual flow to arrive at the requested instream flow.

## BASE FLOW APPROACH

On warm water prairie steams in the Poplar River drainage and the Milk and Little Missouri subbasins, DFWP used a base flow approach (Table C-1). Reservations derived from this method would leave a small amount of water in the stream channel to help ensure fish survival. This low flow would help ensure an exchange of water, freshening the pools, and thus guaranteeing the water quality and dissolved oxygen levels necessary to support fish.

Reservation requests using this "base flow" approach were derived from mean monthly flows calculated by USGS. Mean monthly flows for each stream reach were grouped into two periods: (1) the winter period from December through March; and (2) the non-winter period from April through November. The lowest mean monthly flow for each period was identified and became the flow request for that period.

## RELATIONSHIPS BETWEEN FLOW AND FISH SPAWNING AND REARING

On several streams in the Poplar River drainage and on both reaches of the Missouri River, sufficient understanding of flows necessary for spawning and rearing success enabled DFWP to request reservations based on this information. In the Poplar River drainage, a linear regression analysis showed a strong relationship between April and May flows and production of young walleyes, but weaker relationship was shown between spring flows and production of young northern pike. On the West Fork Poplar River, sufficient information on the relationship between flow and spawning success was not available to base a reservation request on. DFWP's requested reservation is similar to the request made on the East Fork Poplar River.

DFWP requested flows in the Missouri River based in part on the amount of water necessary to protect spawning and rearing habitat for rainbow trout in a side channel immediately downstream from Fort Peck Reservoir, and for sauger spawning areas further downstream. These estimates of instream flow needs entailed use of the computer modelling technique used in the wetted perimeter analysis.

**Table C-1. Streams where DFWP used the base flow approach**

| Milk River Subbasin | Lower Missouri Subbasin | Little Missouri Subbasin |
|---|---|---|
| Battle Creek | Poplar River | Little Missouri River |
| Redwater River reaches and Beaver Creek Reach 2 | Middle Fork Poplar River | Beaver Creek |
| Frenchman River | East Fork Poplar River | Box Elder Creek |
| Rock Creek | West Fork Poplar River | Little Beaver Creek |

# CHANNEL MAINTENANCE FLOWS

DFWP used the dominant discharge concept to develop its channel maintenance flow requests. The concept assumes that dominant discharges (spring bankfull streamflows) are responsible for shaping and maintaining stream channels. DFWP requested flows that peak and recede from the dominant discharge flow over a 13- to 21-day period each spring. The bankfull, or dominant discharges, which DFWP based its reservation requests on were calculated by the USGS. Runoff events of the magnitude requested generally occur about every 2 years (Parrett 1994).

Because bankfull flows are the most efficient flows at eroding and transporting sediment, they play an important role in shaping and maintaining the stream channel. However, research has shown that channel characteristics do not always relate well to bankfull discharge (Knighton 1984). It is likely that a combination of bankfull discharges and other flows throughout the year are necessary to maintain existing stream channel characteristics.

# APPENDIX D

## WATER AVAILABILITY MODELS AND RESULTS

## WATER AVAILABILITY MODELS

Water availability models were developed for the Missouri, Milk, and Little Missouri River subbasins to estimate the effects of proposed reservations on streamflows under each alternative. Each model is based on streamflow and irrigation data from the period between 1928 and 1986.

The Missouri River water availability model described by Dolan and DeLucca (1993) was extended downstream to the North Dakota state line and used to model streamflows in the lower Missouri River and its tributaries (Figure D-1). The Missouri River model uses extended streamflow data (USGS 1989), irrigated acreage data from the past (BUREC undated), and climate data to adjust streamflow values so that data from different years can be compared on an equitable basis despite variations in the amount of irrigated land from year to year. Although any year could have been chosen, all flows were corrected to a 1986 level of irrigation development because it is the last year for which data are available and because irrigation was then near its peak in most subbasins. The model computes streamflows at various locations (nodes) after adjusting for losses (such as water used for irrigation projects), gains (such as tributary inflow between nodes, groundwater return flows), and storage in reservoirs. The Missouri River model is linked to the Milk River basin model at Virgelle (in scenarios that include the Virgelle Diversion) and at the confluence of the Milk River.

The Milk River subbasin was modeled using an adaptation of the BUREC and DNRC OPSTUDY Milk River (Sando and Devore 1987). The OPSTUDY Milk River model (Figure D-2) uses the historic flow of the Milk River at the eastern US/Canadian border crossing and historic and estimated tributary flow volumes to compute the flow of the Milk River in a downstream fashion as it is modified by irrigation diversions, reservoir storage, tributary inflow, and groundwater return flows. Individual water reservation projects were included within the model to assess the impact these projects would have on streamflows in the basin.

Each of the four drainages in the Little Missouri River subbasin were modeled separately. Conceptually, the individual drainage models are simplified versions of the Missouri River model without reservoir storage components and limited to only one node.

The basin models were run for existing conditions and the alternatives described in Chapter Five. Model runs for each of the alternatives are compared to existing conditions in Table D-1 and changes in flow are indicated in Table D-2.

## INTERPRETATION OF MODEL RESULTS

The model results are presented in the tables that include monthly and annual flow statistics. The "mean" is the average of all of the modeled streamflow values for each month. In the case of the difference tables (e.g. Table D-2), the "mean" is the average of the differences between computed flows for the existing conditions and those for alternative or scenario.

The percentile streamflow values give an indication to the distribution of the monthly flows. For example, Table D-1 may be read as "10 percent of the time, the average April streamflow in Battle Creek exceeds 629 cfs." In the case of the difference tables, one might say "10 percent of the time, the difference between average April streamflows in Battle Creek exceeds 18 cfs" (Table D-2).

**Figure D-1. Missouri basin model schematic**

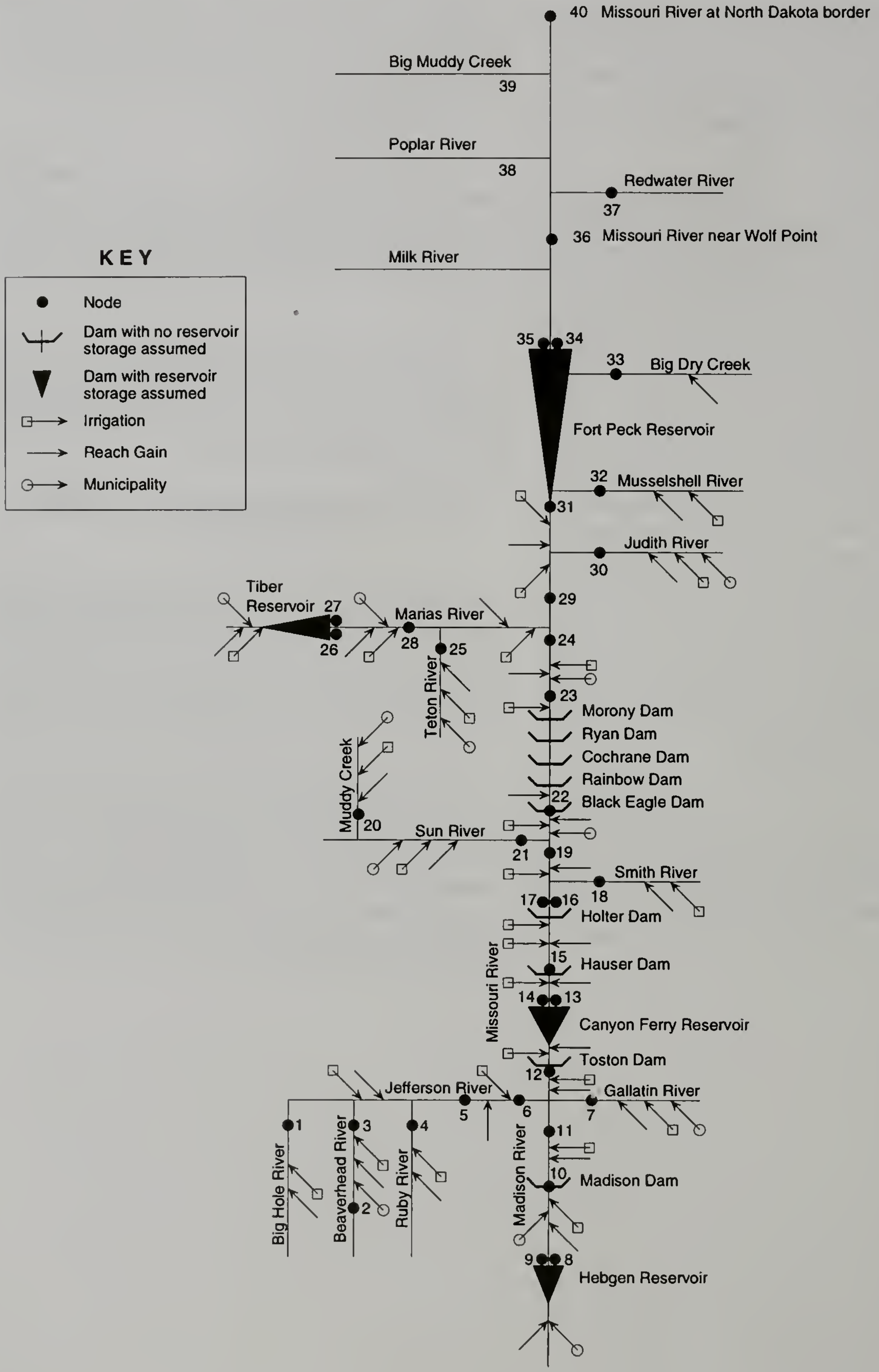


**Figure D-2. Milk River model schematic**

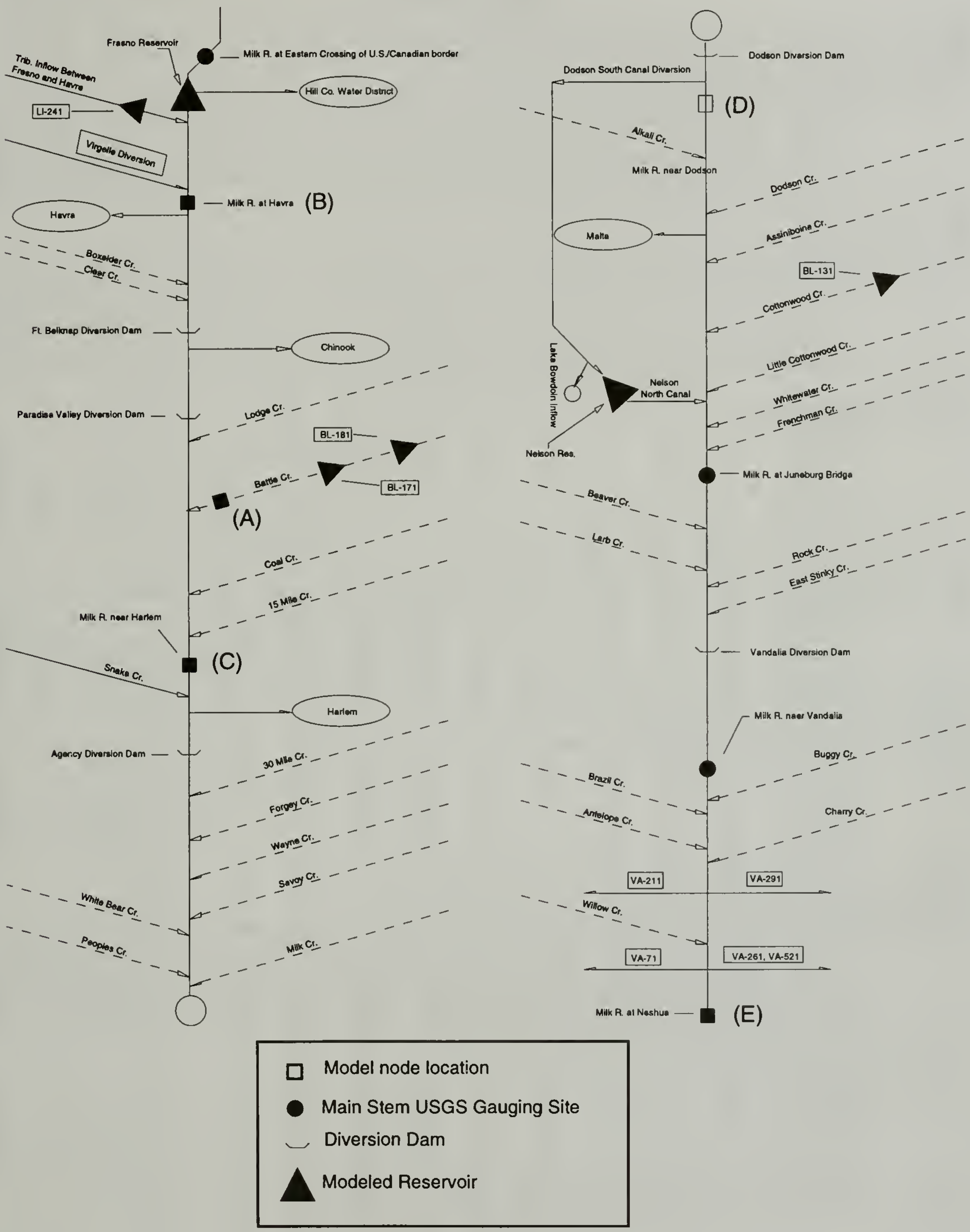


**Table D-1. Monthly streamflow percentile distributions (in cfs)**

**Existing Conditions**

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Missouri River below Fort Peck Dam node 35 | | | | | | | | | | | | | | |
| | AVERAGE | 6418. | 6920. | 10910. | 12081. | 12629. | 8958. | 6404. | 7207. | 7863. | 10449. | 9005. | 7979. | 8891. |
| | 10th% | 12119. | 13533. | 11469. | 13358. | 14442. | 10627. | 9800. | 10728. | 13494. | 15001. | 13331. | 12099. | 11562. |
| | 20th% | 9858. | 10856. | 11283. | 12717. | 13872. | 10276. | 8948. | 9763. | 11794. | 12367. | 11954. | 10756. | 10993. |
| | 50th% | 5287. | 5711. | 10963. | 11985. | 12749. | 9318. | 6617. | 7300. | 7644. | 9876. | 9513. | 8373. | 8770. |
| | 80th% | 2992. | 3008. | 10531. | 11499. | 11374. | 7562. | 3008. | 3884. | 3008. | 7638. | 5452. | 4409. | 6536. |
| | 90th% | 2992. | 3008. | 10203. | 11199. | 10380. | 6461. | 3008. | 2992. | 3008. | 7040. | 3044. | 3008. | 5709. |
| Missouri River near Wolf Point node 36 | | | | | | | | | | | | | | |
| | AVERAGE | 6544. | 7005. | 10754. | 12006. | 12866. | 10940. | 8650. | 7963. | 8568. | 10941. | 9284. | 8295. | 9474. |
| | 10th% | 12078. | 13520. | 11425. | 13324. | 14800. | 15443. | 13794. | 12649. | 14867. | 15088. | 13951. | 12386. | 12514. |
| | 20th% | 9878. | 11294. | 11261. | 12620. | 14028. | 12747. | 11875. | 10612. | 12531. | 13932. | 12755. | 11561. | 11424. |
| | 50th% | 5490. | 5832. | 10882. | 11822. | 12901. | 10670. | 7862. | 7765. | 8441. | 10198. | 9493. | 8376. | 9339. |
| | 80th% | 3074. | 3099. | 10319. | 11376. | 11557. | 8911. | 4743. | 4162. | 3725. | 7969. | 5654. | 4286. | 6706. |
| | 90th% | 3018. | 3059. | 9709. | 11168. | 10440. | 7533. | 3796. | 3183. | 3246. | 7230. | 3224. | 3296. | 6123. |
| Redwater River near Vida node 37 | | | | | | | | | | | | | | |
| | AVERAGE | 7. | 5. | 2. | 1. | 50. | 361. | 115. | 31. | 58. | 33. | 6. | 3. | 56. |
| | 10th% | 11. | 7. | 4. | 4. | 152. | 843. | 280. | 62. | 188. | 96. | 6. | 7. | 120. |
| | 20th% | 10. | 6. | 2. | 2. | 60. | 416. | 68. | 42. | 108. | 21. | 0. | 2. | 88. |
| | 50th% | 7. | 4. | 1. | 1. | 4. | 105. | 27. | 18. | 0. | 0. | 0. | 0. | 30. |
| | 80th% | 5. | 3. | 1. | 0. | 2. | 11. | 10. | 3. | 0. | 0. | 0. | 0. | 11. |
| | 90th% | 4. | 2. | 1. | 0. | 1. | 7. | 8. | 0. | 0. | 0. | 0. | 0. | 6. |
| Poplar River near Poplar node 38 | | | | | | | | | | | | | | |
| | AVERAGE | 31. | 37. | 21. | 9. | 57. | 449. | 710. | 128. | 71. | 24. | 6. | 18. | 130: |
| | 10th% | 47. | 65. | 34. | 17. | 119. | 1405. | 1967. | 346. | 234. | 97. | 21. | 58. | 270. |
| | 20th% | 39. | 45. | 28. | 11. | 51. | 737. | 1074. | 211. | 130. | 32. | 4. | 27. | 227. |
| | 50th% | 28. | 31. | 17. | 6. | 12. | 202. | 241. | 83. | 42. | 0. | 0. | 8. | 92. |
| | 80th% | 20. | 19. | 10. | 3. | 3. | 81. | 98. | 37. | 0. | 0. | 0. | 0. | 49. |
| | 90th% | 16. | 14. | 8. | 2. | 2. | 21. | 86. | 26. | 0. | 0. | 0. | 0. | 35. |
| Big Muddy Creek near Mouth, near Culbertson node 39 | | | | | | | | | | | | | | |
| | AVERAGE | 5. | 1. | 1. | 0. | 6. | 67. | 169. | 93. | 60. | 53. | 29. | 8. | 41. |
| | 10th% | 13. | 5. | 4. | 1. | 12. | 198. | 625. | 254. | 122. | 111. | 78. | 17. | 96. |
| | 20th% | 9. | 3. | 3. | 1. | 3. | 89. | 193. | 132. | 80. | 94. | 53. | 11. | 69. |
| | 50th% | 1. | 0. | 0. | 0. | 0. | 32. | 49. | 40. | 45. | 33. | 20. | 4. | 29. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 1. | 12. | 16. | 15. | 1. | 0. | 0. | 10. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 6. | 8. | 5. | 0. | 0. | 0. | 7. |
| Missouri River at North Dakota Border node 40 | | | | | | | | | | | | | | |
| | AVERAGE | 6675. | 7100. | 10708. | 11892. | 13040. | 12182. | 10246. | 8483. | 9066. | 11376. | 9386. | 8455. | 9873. |
| | 10th% | 12471. | 13342. | 11626. | 13532. | 14884. | 17619. | 17030. | 13245. | 15261. | 16017. | 13909. | 12793. | 13271. |
| | 20th% | 9674. | 11137. | 11327. | 12361. | 14486. | 14138. | 12832. | 11551. | 12985. | 14796. | 13102. | 11783. | 12096. |
| | 50th% | 5579. | 5490. | 10769. | 11817. | 13146. | 11438. | 8845. | 8088. | 8471. | 10737. | 9487. | 8521. | 9800. |
| | 80th% | 3431. | 3115. | 10098. | 11176. | 11900. | 9955. | 5571. | 4400. | 4687. | 8240. | 5254. | 4511. | 7261. |
| | 90th% | 3297. | 2993. | 9597. | 10948. | 10383. | 8409. | 4432. | 3644. | 3489. | 7460. | 3282. | 3499. | 6318. |
| Battle Creek at Mouth node A | | | | | | | | | | | | | | |
| | AVERAGE | 7. | 0. | 0. | 0. | 1. | 141. | 240. | 56. | 30. | 27. | 11. | 18. | 44. |
| | 10th% | 17. | 0. | 0. | 0. | 0. | 567. | 629. | 136. | 85. | 38. | 25. | 16. | 90. |
| | 20th% | 14. | 0. | 0. | 0. | 0. | 232. | 382. | 79. | 59. | 28. | 15. | 8. | 60. |
| | 50th% | 3. | 0. | 0. | 0. | 0. | 64. | 81. | 20. | 10. | 8. | 7. | 1. | 32. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 8. | 20. | 4. | 5. | 3. | 2. | 0. | 11. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 1. | 13. | 3. | 4. | 2. | 1. | 0. | 6. |

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milk River at Havre node B | | | | | | | | | | | | | | |
| | AVERAGE | 237. | 56. | 44. | 42. | 49. | 220. | 454. | 970. | 1002. | 977. | 716. | 350. | 429. |
| | 10th% | 340. | 115. | 74. | 76. | 107. | 512. | 993. | 1323. | 1512. | 1337. | 1134. | 662. | 591. |
| | 20th% | 320. | 68. | 54. | 40. | 63. | 334. | 493. | 1189. | 1330. | 1265. | 829. | 550. | 547. |
| | 50th% | 228. | 38. | 30. | 25. | 32. | 102. | 337. | 965. | 1059. | 1010. | 696. | 328. | 418. |
| | 80th% | 173. | 31. | 25. | 24. | 27. | 47. | 219. | 662. | 581. | 698. | 564. | 155. | 315. |
| | 90th% | 169. | 25. | 24. | 24. | 26. | 29. | 139. | 597. | 508. | 609. | 515. | 65. | 291. |
| Milk River near Harlem node C | | | | | | | | | | | | | | |
| | AVERAGE | 263. | 69. | 46. | 42. | 64. | 504. | 889. | 788. | 599. | 500. | 324. | 334. | 370. |
| | 10th% | 342. | 133. | 74. | 88. | 158. | 1339. | 2121. | 1275. | 914. | 757. | 717. | 506. | 606. |
| | 20th% | 330. | 82. | 55. | 42. | 105. | 910. | 1183. | 888. | 848. | 740. | 532. | 458. | 529. |
| | 50th% | 259. | 55. | 35. | 25. | 37. | 287. | 421. | 749. | 615. | 580. | 277. | 292. | 348. |
| | 80th% | 208. | 40. | 27. | 23. | 25. | 120. | 335. | 534. | 161. | 193. | 147. | 123. | 204. |
| | 90th% | 183. | 37. | 25. | 23. | 25. | 90. | 294. | 325. | 129. | 172. | 106. | 43. | 174. |
| Milk River near Dodson node D | | | | | | | | | | | | | | |
| | AVERAGE | 7. | 85. | 52. | 49. | 118. | 582. | 680. | 232. | 152. | 36. | 1. | 85. | 173. |
| | 10th% | 0. | 148. | 86. | 106. | 320. | 1529. | 2093. | 853. | 235. | 0. | 0. | 49. | 443. |
| | 20th% | 0. | 109. | 65. | 50. | 141. | 1278. | 1039. | 390. | 152. | 0. | 0. | 7. | 279. |
| | 50th% | 0. | 68. | 39. | 28. | 51. | 395. | 47. | 0. | 0. | 0. | 0. | 0. | 113. |
| | 80th% | 0. | 53. | 29. | 23. | 27. | 19. | 0. | 0. | 0. | 0. | 0. | 0. | 49. |
| | 90th% | 0. | 41. | 25. | 23. | 25. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 19. |
| Milk River at Nashua node E | | | | | | | | | | | | | | |
| | AVERAGE | 195. | 171. | 97. | 82. | 198. | 1644. | 1811. | 717. | 514. | 383. | 323. | 360. | 542. |
| | 10th% | 256. | 234. | 136. | 146. | 488. | 4531. | 4971. | 2448. | 1299. | 818. | 599. | 440. | 1163. |
| | 20th% | 236. | 205. | 114. | 91. | 273. | 3051. | 3229. | 989. | 636. | 393. | 490. | 322. | 706. |
| | 50th% | 194. | 155. | 86. | 59. | 100. | 1081. | 768. | 320. | 322. | 261. | 304. | 220. | 442. |
| | 80th% | 149. | 129. | 71. | 53. | 56. | 364. | 198. | 206. | 176. | 114. | 118. | 135. | 227. |
| | 90th% | 126. | 114. | 66. | 52. | 53. | 140. | 124. | 144. | 70. | 31. | 84. | 102. | 157. |
| Little Missouri River near Camp Crook, S.D. | | | | | | | | | | | | | | |
| | AVERAGE | 52.0 | 8.1 | 5.3 | 5.6 | 82.6 | 378.0 | 272.2 | 327.6 | 380.5 | 86.3 | 37.4 | 38.6 | 139.5 |
| | 10% | 93.8 | 11.4 | 8.9 | 11.5 | 331.0 | 937.8 | 827.8 | 1121.0 | 927.9 | 228.0 | 98.9 | 133.0 | 290.0 |
| | 20% | 22.7 | 8.6 | 7.6 | 6.1 | 40.0 | 615.0 | 512.0 | 715.5 | 606.3 | 120.0 | 70.0 | 54.0 | 205.1 |
| | 50% | 3.8 | 4.9 | 4.5 | 2.4 | 5.9 | 193.0 | 71.0 | 69.3 | 221.6 | 45.7 | 16.2 | 5.9 | 112.5 |
| | 80% | 2.4 | 2.8 | 2.5 | 1.2 | 2.3 | 34.3 | 25.1 | 15.8 | 20.9 | 14.9 | 3.6 | 2.2 | 49.3 |
| | 90% | 2.2 | 2.7 | 1.8 | 1.0 | 1.3 | 9.6 | 7.3 | 7.0 | 8.1 | 4.4 | 1.2 | 1.5 | 22.5 |
| Beaver Cr. near Trotters, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 1.1 | 2.5 | 1.1 | 2.1 | 32.2 | 215.9 | 94.9 | 15.8 | 40.8 | 33.0 | 3.5 | 0.6 | 37.0 |
| | 10% | 3.3 | 3.0 | 2.0 | 4.0 | 106.6 | 609.0 | 372.1 | 45.7 | 125.0 | 99.5 | 6.6 | 1.6 | 90.0 |
| | 20% | 2.4 | 1.8 | 1.5 | 1.2 | 34.5 | 446.9 | 109.3 | 19.9 | 57.6 | 25.3 | 2.9 | 0.9 | 66.9 |
| | 50% | 0.5 | 0.7 | 0.9 | 0.5 | 1.9 | 71.4 | 17.9 | 7.8 | 12.2 | 3.4 | 0.4 | 0.2 | 25.9 |
| | 80% | 0.0 | 0.0 | 0.2 | 0.0 | 0.4 | 13.9 | 6.8 | 1.8 | 2.9 | 0.6 | 0.0 | 0.1 | 6.0 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.6 | 3.4 | 0.9 | 1.0 | 0.1 | 0.0 | 0.0 | 3.4 |
| Little Beaver Cr. near Marmath, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 9.7 | 3.2 | 2.9 | 3.3 | 29.0 | 144.8 | 105.7 | 54.7 | 86.7 | 27.9 | 10.1 | 13.7 | 40.9 |
| | 10% | 14.7 | 6.8 | 6.3 | 7.4 | 113.0 | 502.1 | 311.2 | 222.0 | 220.0 | 72.9 | 33.3 | 52.9 | 106.6 |
| | 20% | 7.3 | 4.7 | 3.9 | 2.4 | 40.4 | 248.0 | 138.0 | 76.0 | 132.7 | 37.3 | 11.2 | 18.1 | 64.4 |
| | 50% | 2.2 | 2.7 | 2.2 | 0.7 | 3.9 | 56.5 | 25.4 | 16.1 | 52.9 | 15.6 | 5.2 | 2.5 | 29.1 |
| | 80% | 0.4 | 0.9 | 0.6 | 0.0 | 0.3 | 12.5 | 7.8 | 5.8 | 18.5 | 4.6 | 0.6 | 0.2 | 15.1 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.7 | 5.0 | 2.3 | 4.6 | 1.8 | 0.0 | 0.0 | 8.3 |
| Boxelder Cr. near Webster | | | | | | | | | | | | | | |
| | AVERAGE | 28.1 | 7.4 | 5.1 | 4.4 | 50.7 | 209.8 | 246.3 | 179.5 | 171.1 | 50.5 | 20.6 | 16.9 | 82.5 |
| | 10% | 37.7 | 11.1 | 8.6 | 8.7 | 195.0 | 573.0 | 725.0 | 582.0 | 397.2 | 122.0 | 53.4 | 43.5 | 178.3 |
| | 20% | 17.8 | 8.1 | 6.3 | 6.0 | 47.9 | 407.0 | 294.0 | 397.0 | 266.0 | 72.6 | 32.3 | 25.9 | 126.2 |
| | 50% | 5.3 | 6.1 | 4.5 | 2.9 | 5.2 | 100.1 | 55.7 | 43.7 | 114.9 | 32.0 | 11.8 | 7.6 | 63.6 |
| | 80% | 2.1 | 3.9 | 1.7 | 1.7 | 1.4 | 18.9 | 18.9 | 7.7 | 18.0 | 6.0 | 2.9 | 2.2 | 29.5 |
| | 90% | 1.2 | 2.6 | 0.9 | 1.6 | 0.9 | 11.7 | 13.1 | 3.9 | 6.3 | 3.1 | 1.3 | 0.9 | 17.3 |

**Consumptive Use Alternative**

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Missouri River below Fort Peck Dam node 35 | | | | | | | | | | | | | | |
| | AVERAGE | 6085. | 6556. | 11026. | 12068. | 12617. | 8777. | 6195. | 6981. | 7574. | 10086. | 8686. | 7695. | 8684. |
| | 10th% | 11572. | 12933. | 11582. | 13356. | 14515. | 10540. | 9589. | 10537. | 13149. | 15000. | 13018. | 11794. | 11431. |
| | 20th% | 9374. | 10518. | 11410. | 12716. | 13976. | 10167. | 8682. | 9549. | 11449. | 12117. | 11687. | 10494. | 10820. |
| | 50th% | 4744. | 4992. | 11078. | 11967. | 12823. | 9106. | 6101. | 7077. | 7113. | 9474. | 8961. | 7834. | 8438. |
| | 80th% | 2992. | 3008. | 10500. | 11467. | 11430. | 7316. | 3008. | 3278. | 3008. | 7237. | 5111. | 4076. | 6334. |
| | 90th% | 2992. | 3008. | 10298. | 11179. | 10259. | 5875. | 3008. | 2992. | 3008. | 6658. | 2992. | 3008. | 5540. |
| Missouri River near Wolf Point node 36 | | | | | | | | | | | | | | |
| | AVERAGE | 6248. | 6653. | 10877. | 11997. | 12866. | 10733. | 8481. | 7761. | 8234. | 10543. | 9004. | 8051. | 9276. |
| | 10th% | 11548. | 12915. | 11557. | 13330. | 14920. | 15419. | 13649. | 12473. | 14468. | 15016. | 13668. | 12130. | 12324. |
| | 20th% | 9418. | 10733. | 11386. | 12626. | 14105. | 12602. | 11853. | 10798. | 12073. | 13584. | 12404. | 11301. | 11219. |
| | 50th% | 4805. | 5292. | 11021. | 11826. | 13078. | 10506. | 7498. | 7499. | 7748. | 9917. | 9301. | 8068. | 8952. |
| | 80th% | 3108. | 3104. | 10441. | 11381. | 11625. | 8716. | 4458. | 4064. | 3693. | 7593. | 5329. | 3950. | 6598. |
| | 90th% | 3058. | 3064. | 9796. | 11104. | 10368. | 7265. | 3758. | 3322. | 3098. | 6902. | 3293. | 3216. | 6049. |
| Redwater River near Vida node 37 | | | | | | | | | | | | | | |
| | AVERAGE | 7. | 5. | 2. | 1. | 50. | 361. | 115. | 31. | 58. | 33. | 6. | 3. | 56. |
| | 10th% | 11. | 7. | 4. | 4. | 152. | 843. | 280. | 62. | 188. | 95. | 6. | 7. | 120. |
| | 20th% | 10. | 6. | 2. | 2. | 60. | 416. | 68. | 42. | 108. | 21. | 0. | 2. | 88. |
| | 50th% | 7. | 4. | 1. | 1. | 4. | 105. | 27. | 18. | 0. | 0. | 0. | 0. | 30. |
| | 80th% | 5. | 3. | 1. | 0. | 2. | 11. | 9. | 3. | 0. | 0. | 0. | 0. | 11. |
| | 90th% | 4. | 2. | 1. | 0. | 1. | 7. | 8. | 0. | 0. | 0. | 0. | 0. | 6. |
| Poplar River near Poplar Node 38 | | | | | | | | | | | | | | |
| | AVERAGE | 32. | 37. | 21. | 9. | 57. | 449. | 710. | 126. | 66. | 20. | 5. | 16. | 129. |
| | 10th% | 48. | 65. | 34. | 17. | 119. | 1405. | 1967. | 342. | 228. | 87. | 17. | 59. | 269. |
| | 20th% | 40. | 45. | 29. | 11. | 51. | 737. | 1074. | 210. | 123. | 24. | 0. | 27. | 227. |
| | 50th% | 29. | 32. | 18. | 6. | 12. | 202. | 241. | 78. | 36. | 0. | 0. | 5. | 91. |
| | 80th% | 21. | 20. | 10. | 3. | 3. | 81. | 98. | 34. | 0. | 0. | 0. | 0. | 48. |
| | 90th% | 16. | 15. | 8. | 3. | 2. | 21. | 86. | 22. | 0. | 0. | 0. | 0. | 35. |
| Big Muddy Creek near Mouth, near Culbertson Node 39 | | | | | | | | | | | | | | |
| | AVERAGE | 5. | 1. | 1. | 0. | 6. | 67. | 169. | 93. | 60. | 53. | 29. | 8. | 41. |
| | 10th% | 14. | 5. | 4. | 1. | 12. | 198. | 625. | 254. | 122. | 111. | 78. | 17. | 96. |
| | 20th% | 9. | 3. | 3. | 1. | 3. | 89. | 193. | 132. | 80. | 94. | 53. | 11. | 69. |
| | 50th% | 1. | 0. | 0. | 0. | 0. | 32. | 49. | 39. | 45. | 33. | 20. | 4. | 29. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 1. | 12. | 16. | 15. | 1. | 0. | 0. | 10. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 6. | 8. | 4. | 0. | 0. | 0. | 6. |
| Missouri River at North Dakota Border Node 40 | | | | | | | | | | | | | | |
| | AVERAGE | 6411. | 6774. | 10853. | 11902. | 13058. | 11989. | 10088. | 8235. | 8560. | 10606. | 8822. | 8121. | 9606. |
| | 10th% | 11969. | 12770. | 11790. | 13507. | 14982. | 17367. | 16898. | 12947. | 14751. | 15354. | 13229. | 12350. | 13041. |
| | 20th% | 9241. | 10667. | 11476. | 12397. | 14513. | 14022. | 12825. | 11429. | 12343. | 14036. | 12396. | 11457. | 11788. |
| | 50th% | 4787. | 4893. | 10907. | 11845. | 13218. | 11303. | 8499. | 7849. | 7908. | 9938. | 9091. | 8080. | 9397. |
| | 80th% | 3446. | 3097. | 10241. | 11139. | 11946. | 9588. | 5547. | 4322. | 4348. | 7474. | 4283. | 4150. | 7082. |
| | 90th% | 3359. | 3027. | 9713. | 10957. | 10326. | 8072. | 4347. | 3648. | 3341. | 6558. | 3053. | 3312. | 6158. |
| Battle Creek at Mouth Node A | | | | | | | | | | | | | | |
| | AVERAGE | 9. | 2. | 1. | 1. | 1. | 85. | 179. | 53. | 37. | 47. | 31. | 34. | 40. |
| | 10th% | 27. | 4. | 3. | 3. | 3. | 282. | 430. | 81. | 68. | 63. | 50. | 53. | 79. |
| | 20th% | 15. | 4. | 3. | 3. | 3. | 134. | 229. | 51. | 47. | 47. | 49. | 53. | 53. |
| | 50th% | 4. | 1. | 0. | 0. | 0. | 31. | 56. | 38. | 35. | 43. | 27. | 10. | 27. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 3. | 21. | 12. | 11. | 12. | 8. | 1. | 11. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 12. | 3. | 4. | 4. | 3. | 0. | 6. |

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milk River at Havre Node B | | | | | | | | | | | | | | |
| | AVERAGE | 266. | 59. | 48. | 44. | 59. | 252. | 510. | 1059. | 1102. | 1106. | 915. | 463. | 493. |
| | 10th% | 340. | 125. | 111. | 89. | 126. | 588. | 996. | 1345. | 1346. | 1346. | 1219. | 696. | 630. |
| | 20th% | 323. | 70. | 62. | 45. | 79. | 393. | 698. | 1211. | 1314. | 1311. | 1162. | 644. | 587. |
| | 50th% | 277. | 41. | 31. | 27. | 34. | 125. | 379. | 1018. | 1124. | 1164. | 908. | 461. | 470. |
| | 80th% | 212. | 32. | 25. | 24. | 27. | 49. | 247. | 814. | 875. | 898. | 717. | 269. | 405. |
| | 90th% | 167. | 26. | 24. | 24. | 27. | 31. | 175. | 741. | 603. | 758. | 588. | 216. | 381. |
| Milk River near Harlem Node C | | | | | | | | | | | | | | |
| | AVERAGE | 296. | 74. | 50. | 44. | 73. | 478. | 882. | 868. | 669. | 633. | 519. | 454. | 422. |
| | 10th% | 353. | 138. | 114. | 97. | 158. | 1164. | 1943. | 1302. | 785. | 770. | 733. | 567. | 623. |
| | 20th% | 340. | 95. | 65. | 44. | 104. | 839. | 1221. | 955. | 756. | 756. | 718. | 521. | 544. |
| | 50th% | 310. | 57. | 34. | 27. | 39. | 274. | 449. | 773. | 657. | 696. | 535. | 430. | 384. |
| | 80th% | 261. | 43. | 27. | 22. | 27. | 119. | 352. | 661. | 472. | 450. | 328. | 309. | 288. |
| | 90th% | 216. | 38. | 24. | 22. | 24. | 92. | 247. | 584. | 291. | 277. | 180. | 218. | 257. |
| Milk River near Dodson Node D | | | | | | | | | | | | | | |
| | AVERAGE | 19. | 89. | 55. | 51. | 126. | 554. | 717. | 256. | 118. | 39. | 4. | 86. | 176. |
| | 10th% | 51. | 155. | 116. | 107. | 318. | 1382. | 1905. | 1123. | 319. | 0. | 0. | 132. | 459. |
| | 20th% | 22. | 117. | 73. | 68. | 144. | 1067. | 1094. | 360. | 12. | 0. | 0. | 0. | 291. |
| | 50th% | 0. | 75. | 39. | 29. | 56. | 384. | 147. | 0. | 0. | 0. | 0. | 0. | 127. |
| | 80th% | 0. | 52. | 28. | 22. | 28. | 11. | 0. | 0. | 0. | 0. | 0. | 0. | 44. |
| | 90th% | 0. | 41. | 24. | 21. | 26. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 20. |
| Milk River at Nashua Node E | | | | | | | | | | | | | | |
| | AVERAGE | 229. | 179. | 101. | 84. | 206. | 1616. | 1849. | 752. | 507. | 423. | 421. | 422. | 567. |
| | 10th% | 280. | 264. | 177. | 147. | 489. | 4227. | 4804. | 2579. | 1338. | 906. | 678. | 418. | 1173. |
| | 20th% | 257. | 221. | 119. | 110. | 271. | 2966. | 3316. | 1037. | 668. | 431. | 529. | 345. | 741. |
| | 50th% | 224. | 167. | 86. | 59. | 127. | 1079. | 764. | 350. | 256. | 271. | 422. | 300. | 467. |
| | 80th% | 175. | 132. | 70. | 52. | 58. | 337. | 224. | 220. | 178. | 191. | 295. | 231. | 271. |
| | 90th% | 154. | 121. | 65. | 51. | 54. | 177. | 124. | 202. | 159. | 140. | 225. | 203. | 209. |
| Little Missouri River near Camp Crook, S.D. | | | | | | | | | | | | | | |
| | AVERAGE | 52.2 | 8.3 | 5.4 | 5.6 | 82.7 | 374.9 | 271.5 | 326.7 | 376.4 | 82.0 | 34.5 | 37.1 | 138.1 |
| | 10% | 94.1 | 11.5 | 9.0 | 11.6 | 331.0 | 931.5 | 828.3 | 1114.3 | 922.5 | 216.2 | 95.7 | 131.7 | 288.4 |
| | 20% | 22.7 | 8.8 | 7.7 | 6.1 | 40.0 | 608.3 | 512.5 | 709.6 | 602.0 | 116.1 | 68.0 | 53.3 | 203.5 |
| | 50% | 4.1 | 5.1 | 4.7 | 2.5 | 5.9 | 193.0 | 71.5 | 68.8 | 216.4 | 42.3 | 13.6 | 4.1 | 111.1 |
| | 80% | 2.6 | 3.0 | 2.6 | 1.3 | 2.3 | 34.3 | 25.6 | 14.2 | 18.4 | 10.4 | 0.3 | 0.5 | 48.0 |
| | 90% | 2.4 | 2.8 | 1.9 | 1.0 | 1.4 | 9.6 | 7.3 | 6.7 | 5.6 | 0.7 | 0.0 | 0.0 | 21.6 |
| Beaver Cr. near Trotters, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 1.1 | 2.5 | 1.1 | 2.1 | 32.2 | 200.3 | 94.4 | 15.2 | 36.8 | 31.7 | 3.6 | 0.6 | 35.1 |
| | 10% | 3.3 | 3.0 | 2.0 | 4.0 | 106.6 | 588.0 | 374.0 | 44.2 | 117.1 | 95.8 | 7.3 | 1.7 | 88.1 |
| | 20% | 2.4 | 1.8 | 1.5 | 1.2 | 34.5 | 425.9 | 111.2 | 19.3 | 51.4 | 21.2 | 3.1 | 1.0 | 64.6 |
| | 50% | 0.5 | 0.7 | 0.9 | 0.5 | 1.9 | 50.4 | 16.4 | 7.1 | 8.0 | 4.1 | 0.8 | 0.2 | 23.6 |
| | 80% | 0.0 | 0.0 | 0.2 | 0.0 | 0.4 | 8.3 | 7.3 | 1.8 | 2.9 | 0.7 | 0.1 | 0.1 | 4.4 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.4 | 4.5 | 1.1 | 1.1 | 0.1 | 0.0 | 0.0 | 2.7 |
| Little Beaver Cr. near Marmath, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 9.7 | 3.2 | 2.9 | 3.3 | 29.0 | 139.6 | 104.8 | 54.5 | 83.5 | 26.7 | 9.3 | 13.2 | 39.9 |
| | 10% | 14.7 | 6.8 | 6.3 | 7.4 | 113.0 | 492.7 | 311.2 | 222.1 | 216.8 | 66.4 | 32.6 | 45.8 | 105.3 |
| | 20% | 7.3 | 4.7 | 3.9 | 2.4 | 40.4 | 238.6 | 138.8 | 76.8 | 127.8 | 34.3 | 10.4 | 17.8 | 63.1 |
| | 50% | 2.3 | 2.7 | 2.2 | 0.7 | 3.9 | 47.1 | 26.2 | 16.1 | 45.2 | 14.8 | 4.3 | 2.4 | 27.8 |
| | 80% | 0.4 | 0.9 | 0.6 | 0.0 | 0.3 | 12.5 | 8.0 | 5.8 | 18.1 | 3.8 | 0.1 | 0.0 | 13.7 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.7 | 5.4 | 2.8 | 4.0 | 1.0 | 0.0 | 0.0 | 7.5 |
| Boxelder Cr. near Webster | | | | | | | | | | | | | | |
| | AVERAGE | 28.3 | 7.4 | 5.1 | 4.4 | 50.7 | 207.8 | 246.0 | 178.9 | 168.4 | 46.5 | 17.8 | 15.9 | 81.3 |
| | 10% | 37.7 | 11.1 | 8.6 | 8.7 | 195.0 | 568.6 | 725.4 | 577.6 | 390.7 | 117.4 | 51.2 | 42.9 | 177.0 |
| | 20% | 18.0 | 8.1 | 6.3 | 6.0 | 47.9 | 402.6 | 294.4 | 397.1 | 259.4 | 68.5 | 29.5 | 24.4 | 125.0 |
| | 50% | 5.4 | 6.1 | 4.5 | 2.9 | 5.2 | 100.1 | 56.1 | 43.5 | 113.3 | 29.2 | 9.2 | 6.4 | 62.4 |
| | 80% | 2.3 | 3.9 | 1.7 | 1.7 | 1.4 | 18.9 | 18.9 | 7.5 | 16.1 | 2.4 | 0.0 | 0.6 | 28.3 |
| | 90% | 1.4 | 2.6 | 0.9 | 1.6 | 0.9 | 11.7 | 13.1 | 3.6 | 3.7 | 0.0 | 0.0 | 0.0 | 16.4 |

## Combination Alternative

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Missouri River below Fort Peck Dam Node 35 | | | | | | | | | | | | | | |
| | AVERAGE | 6082. | 6553. | 11028. | 12068. | 12617. | 8774. | 6194. | 6979. | 7573. | 10086. | 8683. | 7693. | 8683. |
| | 10th% | 11572. | 12933. | 11582. | 13356. | 14515. | 10540. | 9589. | 10536. | 13149. | 15000. | 13019. | 11795. | 11431. |
| | 20th% | 9374. | 10516. | 11410. | 12716. | 13976. | 10168. | 8684. | 9550. | 11449. | 12117. | 11687. | 10494. | 10820. |
| | 50th% | 4744. | 4988. | 11078. | 11967. | 12822. | 9105. | 6100. | 7070. | 7101. | 9474. | 8952. | 7826. | 8426. |
| | 80th% | 2992. | 3008. | 10524. | 11467. | 11465. | 7313. | 3008. | 3268. | 3008. | 7238. | 5107. | 4072. | 6331. |
| | 90th% | 2992. | 3008. | 10299. | 11179. | 10256. | 5866. | 3008. | 2992. | 3008. | 6658. | 2992. | 3008. | 5538. |
| Missouri River near Wolf Point Node 36 | | | | | | | | | | | | | | |
| | AVERAGE | 6244. | 6648. | 10878. | 11996. | 12864. | 10785. | 8529. | 7773. | 8242. | 10553. | 9005. | 8051. | 9286. |
| | 10th% | 11547. | 12913. | 11554. | 13327. | 14918. | 15585. | 13652. | 12482. | 14489. | 15029. | 13648. | 12139. | 12340. |
| | 20th% | 9411. | 10732. | 11386. | 12626. | 14103. | 12698. | 11830. | 10902. | 12081. | 13604. | 12417. | 11299. | 11228. |
| | 50th% | 4799. | 5289. | 11028. | 11826. | 13071. | 10528. | 7606. | 7501. | 7711. | 9925. | 9302. | 8071. | 8949. |
| | 80th% | 3107. | 3104. | 10441. | 11378. | 11626. | 8717. | 4458. | 4060. | 3700. | 7606. | 5345. | 3951. | 6618. |
| | 90th% | 3055. | 3060. | 9796. | 11105. | 10364. | 7296. | 3769. | 3325. | 3092. | 6900. | 3304. | 3222. | 6052. |
| Redwater River near Vida Node 37 | | | | | | | | | | | | | | |
| | AVERAGE | 7. | 5. | 2. | 1. | 50. | 361. | 115. | 31. | 58. | 33. | 6. | 3. | 56. |
| | 10th% | 11. | 7. | 4. | 4. | 152. | 843. | 280. | 62. | 188. | 95. | 6. | 7. | 120. |
| | 20th% | 10. | 6. | 2. | 2. | 60. | 416. | 68. | 42. | 108. | 21. | 0. | 2. | 88. |
| | 50th% | 7. | 4. | 1. | 1. | 4. | 105. | 27. | 18. | 0. | 0. | 0. | 0. | 30. |
| | 80th% | 5. | 3. | 1. | 0. | 2. | 11. | 9. | 3. | 0. | 0. | 0. | 0. | 11. |
| | 90th% | 4. | 2. | 1. | 0. | 1. | 7. | 8. | 0. | 0. | 0. | 0. | 0. | 6. |
| Poplar River near Poplar Node 38 | | | | | | | | | | | | | | |
| | AVERAGE | 31. | 37. | 21. | 9. | 57. | 449. | 710. | 127. | 68. | 22. | 5. | 17. | 129. |
| | 10th% | 47. | 65. | 34. | 17. | 119. | 1405. | 1967. | 344. | 231. | 91. | 18. | 58. | 269. |
| | 20th% | 40. | 45. | 28. | 11. | 51. | 737. | 1074. | 210. | 127. | 27. | 1. | 27. | 227. |
| | 50th% | 29. | 32. | 18. | 6. | 12. | 202. | 241. | 80. | 39. | 0. | 0. | 6. | 92. |
| | 80th% | 20. | 20. | 10. | 3. | 3. | 81. | 98. | 36. | 0. | 0. | 0. | 0. | 48. |
| | 90th% | 16. | 15. | 8. | 2. | 2. | 21. | 86. | 24. | 0. | 0. | 0. | 0. | 35. |
| Big Muddy Creek near Mouth, near Culbertson node 39 | | | | | | | | | | | | | | |
| | AVERAGE | 5. | 1. | 1. | 0. | 6. | 67. | 169. | 93. | 60. | 53. | 29. | 8. | 41. |
| | 10th% | 14. | 5. | 4. | 1. | 12. | 198. | 625. | 254. | 122. | 111. | 78. | 17. | 96. |
| | 20th% | 9. | 3. | 3. | 1. | 3. | 89. | 193. | 132. | 80. | 94. | 53. | 11. | 69. |
| | 50th% | 1. | 0. | 0. | 0. | 0. | 32. | 49. | 39. | 45. | 33. | 20. | 4. | 29. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 1. | 12. | 16. | 15. | 1. | 0. | 0. | 10. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 6. | 8. | 4. | 0. | 0. | 0. | 6. |
| Missouri River at North Dakota Border node 40 | | | | | | | | | | | | | | |
| | AVERAGE | 6386. | 6752. | 10840. | 11889. | 13044. | 12032. | 10128. | 8269. | 8652. | 10801. | 8962. | 8161. | 9648. |
| | 10th% | 11951. | 12748. | 11776. | 13510. | 14970. | 17573. | 16890. | 13008. | 14829. | 15527. | 13407. | 12446. | 13102. |
| | 20th% | 9217. | 10643. | 11461. | 12383. | 14500. | 14050. | 12793. | 11423. | 12478. | 14268. | 12598. | 11487. | 11828. |
| | 50th% | 4767. | 4873. | 10927. | 11831. | 13201. | 11332. | 8688. | 7859. | 7929. | 10063. | 9174. | 8152. | 9433. |
| | 80th% | 3437. | 3079. | 10224. | 11128. | 11929. | 9577. | 5540. | 4354. | 4409. | 7702. | 4409. | 4152. | 7128. |
| | 90th% | 3342. | 3003. | 9700. | 10946. | 10304. | 8048. | 4438. | 3644. | 3448. | 6791. | 3211. | 3364. | 6191. |
| Battle Creek at Mouth node A | | | | | | | | | | | | | | |
| | AVERAGE | 7. | 0. | 0. | 0. | 1. | 141. | 240. | 56. | 30. | 27. | 11. | 18. | 44. |
| | 10th% | 17. | 0. | 0. | 0. | 0. | 567. | 629. | 136. | 85. | 38. | 25. | 16. | 90. |
| | 20th% | 14. | 0. | 0. | 0. | 0. | 232. | 382. | 79. | 59. | 28. | 15. | 8. | 60. |
| | 50th% | 3. | 0. | 0. | 0. | 0. | 64. | 81. | 20. | 10. | 8. | 7. | 1. | 32. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 8. | 20. | 4. | 5. | 3. | 2. | 0. | 11. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 1. | 13. | 3. | 4. | 2. | 1. | 0. | 6. |

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milk River at Havre node B | | | | | | | | | | | | | | |
| | AVERAGE | 267. | 58. | 48. | 44. | 57. | 250. | 505. | 1070. | 1111. | 1109. | 914. | 471. | 495. |
| | 10th% | 344. | 116. | 102. | 78. | 126. | 586. | 996. | 1376. | 1385. | 1363. | 1238. | 748. | 629. |
| | 20th% | 327. | 70. | 62. | 45. | 67. | 393. | 638. | 1235. | 1310. | 1328. | 1174. | 659. | 587. |
| | 50th% | 278. | 41. | 31. | 26. | 34. | 122. | 387. | 1017. | 1135. | 1179. | 901. | 455. | 471. |
| | 80th% | 208. | 32. | 25. | 24. | 27. | 48. | 254. | 871. | 871. | 892. | 715. | 269. | 407. |
| | 90th% | 170. | 26. | 24. | 24. | 27. | 29. | 143. | 753. | 594. | 766. | 597. | 241. | 382. |
| Milk River near Harlem node C | | | | | | | | | | | | | | |
| | AVERAGE | 296. | 72. | 49. | 44. | 71. | 533. | 939. | 884. | 673. | 617. | 499. | 446. | 429. |
| | 10th% | 353. | 133. | 103. | 87. | 157. | 1337. | 2120. | 1388. | 785. | 767. | 732. | 563. | 649. |
| | 20th% | 342. | 94. | 62. | 45. | 105. | 909. | 1246. | 960. | 751. | 754. | 712. | 517. | 575. |
| | 50th% | 310. | 57. | 34. | 26. | 38. | 307. | 499. | 773. | 668. | 692. | 535. | 423. | 386. |
| | 80th% | 246. | 42. | 27. | 23. | 26. | 131. | 338. | 675. | 473. | 407. | 294. | 293. | 294. |
| | 90th% | 195. | 37. | 24. | 23. | 25. | 95. | 238. | 573. | 276. | 273. | 162. | 218. | 260. |
| Milk River near Dodson node D | | | | | | | | | | | | | | |
| | AVERAGE | 19. | 87. | 55. | 50. | 125. | 609. | 767. | 267. | 121. | 38. | 2. | 86. | 185. |
| | 10th% | 47. | 148. | 117. | 105. | 319. | 1585. | 2101. | 1207. | 308. | 0. | 0. | 110. | 465. |
| | 20th% | 24. | 117. | 72. | 66. | 140. | 1277. | 1234. | 356. | 0. | 0. | 0. | 0. | 318. |
| | 50th% | 0. | 72. | 38. | 28. | 57. | 394. | 173. | 0. | 0. | 0. | 0. | 0. | 131. |
| | 80th% | 0. | 53. | 28. | 22. | 27. | 43. | 0. | 0. | 0. | 0. | 0. | 0. | 47. |
| | 90th% | 0. | 42. | 25. | 22. | 24. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 22. |
| Milk River at Nashua node E | | | | | | | | | | | | | | |
| | AVERAGE | 228. | 178. | 100. | 84. | 205. | 1671. | 1899. | 763. | 509. | 420. | 413. | 419. | 575. |
| | 10th% | 267. | 243. | 174. | 145. | 487. | 4507. | 4970. | 2605. | 1327. | 907. | 611. | 442. | 1176. |
| | 20th% | 256. | 222. | 116. | 107. | 272. | 3049. | 3430. | 1014. | 635. | 431. | 529. | 341. | 741. |
| | 50th% | 222. | 167. | 85. | 59. | 118. | 1080. | 848. | 350. | 250. | 265. | 420. | 298. | 478. |
| | 80th% | 177. | 133. | 70. | 52. | 59. | 363. | 224. | 220. | 181. | 188. | 265. | 231. | 272. |
| | 90th% | 154. | 122. | 66. | 51. | 53. | 189. | 124. | 203. | 155. | 135. | 223. | 199. | 208. |
| Little Missouri River near Camp Crook, S.D. | | | | | | | | | | | | | | |
| | AVERAGE | 52.2 | 8.3 | 5.4 | 5.6 | 82.7 | 375.0 | 271.5 | 326.7 | 376.4 | 81.9 | 34.5 | 37.0 | 138.1 |
| | 10% | 94.1 | 11.5 | 9.0 | 11.6 | 331.0 | 931.9 | 828.3 | 1114.3 | 922.5216.2 | 95.7 | 131.7 | 288.4 | |
| | 20% | 22.7 | 8.8 | 7.7 | 6.1 | 40.0 | 608.3 | 512.5 | 709.9 | 602.0 | 116.1 | 68.0 | 53.3 | 203.4 |
| | 50% | 4.1 | 5.1 | 4.7 | 2.5 | 5.9 | 193.0 | 71.5 | 68.8 | 216.4 | 42.3 | 13.6 | 4.1 | 111.1 |
| | 80% | 2.6 | 3.0 | 2.6 | 1.3 | 2.3 | 34.3 | 25.6 | 14.2 | 18.4 | 10.4 | 0.3 | 0.5 | 48.0 |
| | 90% | 2.4 | 2.8 | 1.9 | 1.0 | 1.3 | 9.6 | 7.3 | 6.7 | 5.6 | 0.7 | 0.0 | 0.0 | 21.6 |
| Beaver Cr. near Trotters, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 1.1 | 2.5 | 1.1 | 2.1 | 32.2 | 211.9 | 95.0 | 15.6 | 39.7 | 32.6 | 3.5 | 0.6 | 36.5 |
| | 10% | 3.3 | 3.0 | 2.0 | 4.0 | 106.6 | 604.4 | 372.5 | 45.4 | 123.3 | 98.3 | 6.7 | 1.6 | 89.5 |
| | 20% | 2.4 | 1.8 | 1.5 | 1.2 | 34.5 | 442.3 | 109.7 | 20.0 | 57.2 | 24.7 | 2.9 | 1.0 | 66.4 |
| | 50% | 0.5 | 0.7 | 0.9 | 0.5 | 1.9 | 66.8 | 18.2 | 7.2 | 10.2 | 3.5 | 0.5 | 0.2 | 25.4 |
| | 80% | 0.0 | 0.0 | 0.2 | 0.0 | 0.4 | 9.3 | 6.9 | 1.8 | 2.9 | 0.6 | 0.1 | 0.1 | 5.5 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.3 | 3.7 | 1.0 | 1.0 | 0.1 | 0.0 | 0.0 | 3.0 |
| Little Beaver Cr. near Marmath, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 9.7 | 3.2 | 2.9 | 3.3 | 29.0 | 141.1 | 105.0 | 54.5 | 84.4 | 26.9 | 9.5 | 13.4 | 40.2 |
| | 10% | 14.7 | 6.8 | 6.3 | 7.4 | 113.0 | 495.5 | 311.2 | 222.0 | 217.7 | 68.3 | 32.7 | 49.4 | 105.7 |
| | 20% | 7.3 | 4.7 | 3.9 | 2.4 | 40.4 | 241.4 | 138.6 | 76.6 | 129.2 | 34.5 | 10.6 | 17.9 | 63.4 |
| | 50% | 2.3 | 2.7 | 2.2 | 0.7 | 3.9 | 49.9 | 26.0 | 16.1 | 46.7 | 15.0 | 4.5 | 2.4 | 28.2 |
| | 80% | 0.4 | 0.9 | 0.6 | 0.0 | 0.3 | 12.5 | 7.8 | 5.8 | 18.2 | 3.9 | 0.3 | 0.0 | 14.1 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.7 | 5.2 | 2.8 | 4.2 | 1.1 | 0.0 | 0.0 | 7.5 |
| Boxelder Cr. near Webster | | | | | | | | | | | | | | |
| | AVERAGE | 28.2 | 7.4 | 5.1 | 4.4 | 50.7 | 208.2 | 246.0 | 179.0 | 169.2 | 47.9 | 18.7 | 16.2 | 81.7 |
| | 10% | 37.7 | 11.1 | 8.6 | 8.7 | 195.0 | 569.4 | 725.4 | 578.4 | 392.1 | 119.0 | 52.0 | 43.0 | 177.4 |
| | 20% | 17.9 | 8.1 | 6.3 | 6.0 | 47.9 | 403.4 | 294.4 | 397.1 | 260.8 | 69.8 | 30.6 | 25.0 | 125.4 |
| | 50% | 5.4 | 6.1 | 4.5 | 2.9 | 5.2 | 100.1 | 56.1 | 43.6 | 113.9 | 30.3 | 10.2 | 6.9 | 62.7 |
| | 80% | 2.2 | 3.9 | 1.7 | 1.7 | 1.4 | 18.9 | 18.9 | 7.6 | 16.8 | 3.6 | 1.0 | 1.3 | 28.7 |
| | 90% | 1.3 | 2.6 | 0.9 | 1.6 | 0.9 | 11.7 | 13.1 | 3.7 | 4.7 | 0.6 | 0.0 | 0.1 | 16.7 |

## Instream Alternative

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Missouri River below Fort Peck Dam node 35 | | | | | | | | | | | | | | |
| | AVERAGE | 6082. | 6553. | 11028. | 12068. | 12617. | 8774. | 6194. | 6979. | 7573. | 10086. | 8683. | 7693. | 8683. |
| | 10th% | 11572. | 12933. | 11582. | 13356. | 14515. | 10540. | 9589. | 10536. | 13149. | 15000. | 13019. | 11794. | 11431. |
| | 20th% | 9373. | 10516. | 11410. | 12716. | 13976. | 10168. | 8684. | 9550. | 11449. | 12117. | 11687. | 10494. | 10820. |
| | 50th% | 4744. | 4988. | 11078. | 11967. | 12822. | 9105. | 6100. | 7070. | 7100. | 9474. | 8952. | 7825. | 8426. |
| | 80th% | 2992. | 3008. | 10524. | 11467. | 11465. | 7313. | 3008. | 3268. | 3008. | 7238. | 5107. | 4072. | 6331. |
| | 90th% | 2992. | 3008. | 10299. | 11179. | 10256. | 5865. | 3008. | 2992. | 3008. | 6658. | 2992. | 3008. | 5538. |
| Missouri River near Wolf Point node 36 | | | | | | | | | | | | | | |
| | AVERAGE | 6240. | 6644. | 10874. | 11992. | 12861. | 10782. | 8525. | 7781. | 8275. | 10617. | 9053. | 8068. | 9298. |
| | 10th% | 11544. | 12909. | 11551. | 13324. | 14914. | 15581. | 13650. | 12501. | 14525. | 15088. | 13678. | 12169. | 12350. |
| | 20th% | 9408. | 10728. | 11383. | 12623. | 14099. | 12694. | 11822. | 10899. | 12121. | 13680. | 12479. | 11313. | 11245. |
| | 50th% | 4796. | 5285. | 11024. | 11822. | 13068. | 10519. | 7601. | 7508. | 7724. | 9962. | 9345. | 8096. | 8963. |
| | 80th% | 3104. | 3100. | 10438. | 11375. | 11622. | 8715. | 4457. | 4083. | 3724. | 7669. | 5412. | 3953. | 6630. |
| | 90th% | 3050. | 3057. | 9793. | 11100. | 10361. | 7293. | 3766. | 3342. | 3115. | 6982. | 3347. | 3248. | 6065. |
| Redwater River near Vida node 37 | | | | | | | | | | | | | | |
| | AVERAGE | 7. | 5. | 2. | 1. | 50. | 361. | 115. | 31. | 58. | 33. | 6. | 3. | 56. |
| | 10th% | 11. | 7. | 4. | 4. | 152. | 843. | 280. | 62. | 188. | 95. | 6. | 7. | 120. |
| | 20th% | 10. | 6. | 2. | 2. | 60. | 416. | 68. | 42. | 108. | 21. | 0. | 2. | 88. |
| | 50th% | 7. | 4. | 1. | 1. | 4. | 105. | 27. | 18. | 0. | 0. | 0. | 0. | 30. |
| | 80th% | 5. | 3. | 1. | 0. | 2. | 11. | 9. | 3. | 0. | 0. | 0. | 0. | 11. |
| | 90th% | 4. | 2. | 1. | 0. | 1. | 7. | 8. | 0. | 0. | 0. | 0. | 0. | 6. |
| Poplar River near Poplar node 38 | | | | | | | | | | | | | | |
| | AVERAGE | 31. | 37. | 21. | 9. | 57. | 449. | 710. | 128. | 70. | 24. | 6. | 18. | 130. |
| | 10th% | 47. | 65. | 34. | 17. | 119. | 1405. | 1967. | 346. | 234. | 97. | 21. | 58. | 270. |
| | 20th% | 39. | 45. | 28. | 11. | 51. | 737. | 1074. | 210. | 130. | 31. | 4. | 27. | 227. |
| | 50th% | 28. | 31. | 17. | 6. | 12. | 202. | 241. | 82. | 42. | 0. | 0. | 8. | 92. |
| | 80th% | 20. | 19. | 10. | 3. | 3. | 81. | 97. | 37. | 0. | 0. | 0. | 0. | 49. |
| | 90th% | 16. | 14. | 8. | 2. | 2. | 20. | 86. | 26. | 0. | 0. | 0. | 0. | 35. |
| Big Muddy Creek near Mouth, near Culbertson node 39 | | | | | | | | | | | | | | |
| | AVERAGE | 5. | 1. | 1. | 0. | 6. | 67. | 169. | 93. | 60. | 53. | 29. | 8. | 41. |
| | 10th% | 14. | 5. | 4. | 1. | 12. | 198. | 625. | 254. | 122. | 111. | 78. | 17. | 96. |
| | 20th% | 9. | 3. | 3. | 1. | 3. | 89. | 193. | 132. | 80. | 94. | 53. | 11. | 69. |
| | 50th% | 1. | 0. | 0. | 0. | 0. | 32. | 49. | 39. | 45. | 33. | 20. | 4. | 29. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 1. | 12. | 16. | 15. | 1. | 0. | 0. | 10. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 6. | 8. | 4. | 0. | 0. | 0. | 6. |
| Missouri River at North Dakota Border node 40 | | | | | | | | | | | | | | |
| | AVERAGE | 6371. | 6738. | 10828. | 11879. | 13034. | 12023. | 10121. | 8300. | 8769. | 11046. | 9149. | 8226. | 9695. |
| | 10th% | 11937. | 12730. | 11764. | 13509. | 14961. | 17572. | 16883. | 13080. | 14919. | 15763. | 13633. | 12554. | 13144. |
| | 20th% | 9203. | 10630. | 11451. | 12373. | 14488. | 14043. | 12779. | 11422. | 12620. | 14493. | 12861. | 11530. | 11887. |
| | 50th% | 4755. | 4855. | 10913. | 11820. | 13190. | 11325. | 8677. | 7888. | 8016. | 10292. | 9339. | 8251. | 9490. |
| | 80th% | 3421. | 3067. | 10211. | 11119. | 11919. | 9569. | 5534. | 4398. | 4494. | 7969. | 4611. | 4188. | 7184. |
| | 90th% | 3330. | 2987. | 9688. | 10935. | 10292. | 8039. | 4429. | 3643. | 3587. | 7109. | 3415. | 3428. | 6239. |
| Battle Creek at Mouth node A | | | | | | | | | | | | | | |
| | AVERAGE | 7. | 0. | 0. | 0. | 1. | 141. | 240. | 56. | 30. | 27. | 11. | 18. | 44. |
| | 10th% | 17. | 0. | 0. | 0. | 0. | 567. | 629. | 136. | 85. | 38. | 25. | 16. | 90. |
| | 20th% | 14. | 0. | 0. | 0. | 0. | 232. | 382. | 79. | 59. | 28. | 15. | 8. | 60. |
| | 50th% | 3. | 0. | 0. | 0. | 0. | 64. | 81. | 20. | 10. | 8. | 7. | 1. | 32. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 8. | 20. | 4. | 5. | 3. | 2. | 0. | 11. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 1. | 13. | 3. | 4. | 2. | 1. | 0. | 6. |

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milk River at Havre node B | | | | | | | | | | | | | | |
| | AVERAGE | 268. | 58. | 48. | 44. | 57. | 250. | 505. | 1071. | 1111. | 1109. | 914. | 471. | 495. |
| | 10th% | 345. | 116. | 102. | 77. | 126. | 586. | 996. | 1377. | 1386. | 1365. | 1240. | 749. | 629. |
| | 20th% | 328. | 70. | 62. | 45. | 67. | 393. | 634. | 1236. | 1307. | 1329. | 1175. | 655. | 586. |
| | 50th% | 279. | 41. | 31. | 26. | 34. | 122. | 388. | 1014. | 1137. | 1180. | 901. | 455. | 471. |
| | 80th% | 212. | 32. | 25. | 24. | 27. | 49. | 252. | 865. | 872. | 892. | 715. | 269. | 408. |
| | 90th% | 171. | 26. | 24. | 24. | 27. | 29. | 143. | 755. | 594. | 766. | 598. | 242. | 382. |
| Milk River near Harlem node C | | | | | | | | | | | | | | |
| | AVERAGE | 296. | 71. | 48. | 42. | 70. | 532. | 938. | 883. | 672. | 616. | 497. | 445. | 428. |
| | 10th% | 353. | 132. | 102. | 86. | 156. | 1336. | 2119. | 1387. | 785. | 767. | 732. | 563. | 647. |
| | 20th% | 342. | 93. | 61. | 44. | 104. | 907. | 1241. | 959. | 751. | 754. | 712. | 510. | 574. |
| | 50th% | 309. | 56. | 33. | 25. | 37. | 306. | 498. | 773. | 668. | 692. | 535. | 423. | 385. |
| | 80th% | 247. | 41. | 26. | 22. | 25. | 131. | 338. | 675. | 468. | 404. | 292. | 293. | 293. |
| | 90th% | 195. | 36. | 23. | 22. | 24. | 95. | 238. | 569. | 276. | 271. | 161. | 218. | 259. |
| Milk River near Dodson node D | | | | | | | | | | | | | | |
| | AVERAGE | 19. | 86. | 54. | 49. | 124. | 608. | 765. | 266. | 121. | 38. | 2. | 86. | 184. |
| | 10th% | 46. | 147. | 116. | 104. | 318. | 1583. | 2097. | 1206. | 301. | 0. | 0. | 101. | 464. |
| | 20th% | 24. | 116. | 71. | 65. | 139. | 1276. | 1230. | 355. | 0. | 0. | 0. | 0. | 317. |
| | 50th% | 0. | 71. | 37. | 27. | 56. | 393. | 171. | 0. | 0. | 0. | 0. | 0. | 130. |
| | 80th% | 0. | 52. | 27. | 21. | 26. | 42. | 0. | 0. | 0. | 0. | 0. | 0. | 46. |
| | 90th% | 0. | 41. | 24. | 21. | 23. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 21. |
| Milk River at Nashua node E | | | | | | | | | | | | | | |
| | AVERAGE | 228. | 176. | 99. | 83. | 204. | 1670. | 1897. | 763. | 513. | 424. | 415. | 420. | 576. |
| | 10th% | 267. | 242. | 173. | 144. | 486. | 4506. | 4969. | 2603. | 1322. | 912. | 609. | 441. | 1175. |
| | 20th% | 256. | 221. | 115. | 105. | 271. | 3048. | 3425. | 1013. | 641. | 435. | 530. | 340. | 741. |
| | 50th% | 222. | 166. | 84. | 58. | 116. | 1079. | 848. | 350. | 254. | 270. | 424. | 297. | 479. |
| | 80th% | 176. | 132. | 69. | 51. | 58. | 362. | 224. | 221. | 186. | 193. | 266. | 230. | 272. |
| | 90th% | 154. | 121. | 65. | 50. | 52. | 188. | 124. | 205. | 162. | 139. | 225. | 200. | 209. |
| Little Missouri River near Camp Crook, S.D. | | | | | | | | | | | | | | |
| | AVERAGE | 52.0 | 8.2 | 5.3 | 5.6 | 82.6 | 378.0 | 272.2 | 327.4 | 379.3 | 84.1 | 36.2 | 38.3 | 139.1 |
| | 10% | 93.8 | 11.4 | 8.9 | 11.5 | 331.0 | 937.8 | 827.8 | 1121.0 | 926.4 | 224.7 | 96.8 | 132.1 | 289.5 |
| | 20% | 22.7 | 8.6 | 7.6 | 6.1 | 40.0 | 615.0 | 512.0 | 715.5 | 605.2 | 117.5 | 68.8 | 53.6 | 204.8 |
| | 50% | 3.9 | 4.9 | 4.5 | 2.4 | 5.9 | 193.0 | 71.0 | 69.0 | 219.3 | 43.8 | 14.7 | 6.0 | 112.1 |
| | 80% | 2.5 | 2.9 | 2.5 | 1.2 | 2.3 | 34.3 | 25.1 | 14.8 | 19.4 | 12.3 | 3.7 | 2.3 | 48.9 |
| | 90% | 2.3 | 2.7 | 1.8 | 1.0 | 1.3 | 9.6 | 7.3 | 7.0 | 6.6 | 4.4 | 1.3 | 1.6 | 22.1 |
| Beaver Cr. near Trotters, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 1.1 | 2.5 | 1.1 | 2.1 | 32.2 | 211.9 | 95.0 | 15.6 | 39.7 | 32.6 | 3.5 | 0.6 | 36.5 |
| | 10% | 3.3 | 3.0 | 2.0 | 4.0 | 106.6 | 604.4 | 372.5 | 45.4 | 123.3 | 98.3 | 6.7 | 1.6 | 89.5 |
| | 20% | 2.4 | 1.8 | 1.5 | 1.2 | 34.5 | 442.3 | 109.7 | 20.0 | 57.2 | 24.7 | 2.9 | 1.0 | 66.4 |
| | 50% | 0.5 | 0.7 | 0.9 | 0.5 | 1.9 | 66.8 | 18.2 | 7.2 | 10.2 | 3.5 | 0.5 | 0.2 | 25.4 |
| | 80% | 0.0 | 0.0 | 0.2 | 0.0 | 0.4 | 9.3 | 6.9 | 1.8 | 2.9 | 0.6 | 0.1 | 0.1 | 5.5 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.3 | 3.7 | 1.0 | 1.0 | 0.1 | 0.0 | 0.0 | 3.0 |
| Little Beaver Cr. near Marmath, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 9.7 | 3.2 | 2.9 | 3.3 | 29.0 | 144.8 | 105.7 | 54.7 | 86.4 | 27.3 | 9.8 | 13.6 | 40.8 |
| | 10% | 14.7 | 6.8 | 6.3 | 7.4 | 113.0 | 502.1 | 311.1 | 222.0 | 219.8 | 72.0 | 32.7 | 52.7 | 106.4 |
| | 20% | 7.3 | 4.7 | 3.9 | 2.4 | 40.4 | 248.0 | 138.0 | 76.0 | 132.2 | 36.6 | 10.6 | 17.9 | 64.2 |
| | 50% | 2.2 | 2.7 | 2.2 | 0.7 | 3.9 | 56.5 | 25.4 | 16.1 | 52.7 | 14.8 | 4.5 | 2.5 | 29.0 |
| | 80% | 0.4 | 0.9 | 0.6 | 0.0 | 0.3 | 12.5 | 7.8 | 5.8 | 18.2 | 3.8 | 0.6 | 0.2 | 14.9 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.7 | 5.0 | 2.3 | 4.2 | 1.8 | 0.0 | 0.0 | 8.3 |
| Boxelder Cr. near Webster | | | | | | | | | | | | | | |
| | AVERAGE | 28.2 | 7.4 | 5.1 | 4.4 | 50.7 | 209.8 | 246.3 | 179.4 | 170.5 | 49.4 | 19.9 | 16.8 | 82.2 |
| | 10% | 37.7 | 11.1 | 8.6 | 8.7 | 195.0 | 573.0 | 725.0 | 582.0 | 396.8 | 120.6 | 52.6 | 43.2 | 177.9 |
| | 20% | 17.8 | 8.1 | 6.3 | 6.0 | 47.9 | 407.0 | 294.0 | 397.0 | 265.6 | 70.8 | 31.3 | 25.4 | 125.9 |
| | 50% | 5.3 | 6.1 | 4.5 | 2.9 | 5.2 | 100.1 | 55.7 | 43.6 | 114.4 | 31.2 | 10.9 | 7.1 | 63.4 |
| | 80% | 2.2 | 3.9 | 1.7 | 1.7 | 1.4 | 18.9 | 18.9 | 7.6 | 17.3 | 6.0 | 3.0 | 2.2 | 29.3 |
| | 90% | 1.2 | 2.6 | 0.9 | 1.6 | 0.9 | 11.7 | 13.1 | 3.9 | 6.3 | 3.1 | 1.3 | 1.0 | 17.0 |

## No Action Alternative

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Missouri River below Fort Peck Dam node 35 | | | | | | | | | | | | | | |
| | AVERAGE | 6108. | 6583. | 11027. | 12084. | 12630. | 8791. | 6214. | 7001. | 7596. | 10095. | 8707. | 7715. | 8701. |
| | 10th% | 11614. | 12983. | 11584. | 13361. | 14526. | 10550. | 9613. | 10559. | 13181. | 15000. | 13043. | 11818. | 11449. |
| | 20th% | 9412. | 10557. | 11407. | 12719. | 13980. | 10180. | 8713. | 9572. | 11482. | 12130. | 11710. | 10517. | 10839. |
| | 50th% | 4772. | 5022. | 11079. | 11975. | 12832. | 9123. | 6142. | 7091. | 7134. | 9475. | 8976. | 7849. | 8450. |
| | 80th% | 2992. | 3008. | 10672. | 11506. | 11440. | 7326. | 3008. | 3296. | 3008. | 7241. | 5123. | 4088. | 6340. |
| | 90th% | 2992. | 3008. | 10294. | 11194. | 10248. | 5919. | 3008. | 2992. | 3008. | 6661. | 2992. | 3008. | 5546. |
| Missouri River near Wolf Point node 36 | | | | | | | | | | | | | | |
| | AVERAGE | 6267. | 6676. | 10876. | 12010. | 12875. | 10801. | 8551. | 7804. | 8300. | 10629. | 9080. | 8092. | 9319. |
| | 10th% | 11587. | 12953. | 11551. | 13331. | 14917. | 15597. | 13664. | 12526. | 14567. | 15088. | 13714. | 12194. | 12374. |
| | 20th% | 9446. | 10775. | 11386. | 12625. | 14110. | 12706. | 11866. | 10971. | 12154. | 13688. | 12515. | 11341. | 11268. |
| | 50th% | 4825. | 5333. | 11016. | 11825. | 13015. | 10547. | 7627. | 7536. | 7778. | 9976. | 9371. | 8112. | 8985. |
| | 80th% | 3104. | 3102. | 10437. | 11390. | 11630. | 8734. | 4502. | 4111. | 3724. | 7676. | 5432. | 3971. | 6639. |
| | 90th% | 3052. | 3059. | 9796. | 11143. | 10371. | 7307. | 3768. | 3342. | 3116. | 6990. | 3354. | 3248. | 6071. |
| Redwater River near Vida node 37 | | | | | | | | | | | | | | |
| | AVERAGE | 7. | 5. | 2. | 1. | 50. | 361. | 115. | 31. | 58. | 33. | 6. | 3. | 56. |
| | 10th% | 11. | 7. | 4. | 4. | 152. | 843. | 280. | 62. | 188. | 95. | 6. | 7. | 120. |
| | 20th% | 10. | 6. | 2. | 2. | 60. | 416. | 68. | 42. | 108. | 21. | 0. | 2. | 88. |
| | 50th% | 7. | 4. | 1. | 1. | 4. | 105. | 27. | 18. | 0. | 0. | 0. | 0. | 30. |
| | 80th% | 5. | 3. | 1. | 0. | 2. | 11. | 9. | 3. | 0. | 0. | 0. | 0. | 11. |
| | 90th% | 4. | 2. | 1. | 0. | 1. | 7. | 8. | 0. | 0. | 0. | 0. | 0. | 6. |
| Poplar River near Poplar node 38 | | | | | | | | | | | | | | |
| | AVERAGE | 31. | 37. | 21. | 9. | 57. | 449. | 710. | 128. | 71. | 24. | 6. | 18. | 130. |
| | 10th% | 47. | 65. | 34. | 17. | 119. | 1405. | 1967. | 346. | 234. | 97. | 21. | 58. | 270. |
| | 20th% | 39. | 45. | 28. | 11. | 51. | 737. | 1074. | 210. | 130. | 31. | 4. | 27. | 227. |
| | 50th% | 28. | 31. | 17. | 6. | 12. | 202. | 241. | 82. | 42. | 0. | 0. | 8. | 92. |
| | 80th% | 20. | 19. | 10. | 3. | 3. | 81. | 97. | 37. | 0. | 0. | 0. | 0. | 49. |
| | 90th% | 16. | 14. | 8. | 2. | 2. | 20. | 86. | 26. | 0. | 0. | 0. | 0. | 35. |
| Big Muddy Creek near Mouth, near Culbertson node 39 | | | | | | | | | | | | | | |
| | AVERAGE | 5. | 1. | 1. | 0. | 6. | 67. | 169. | 93. | 60. | 53. | 29. | 8. | 41. |
| | 10th% | 13. | 5. | 4. | 1. | 12. | 198. | 625. | 254. | 122. | 111. | 78. | 17. | 96. |
| | 20th% | 9. | 3. | 3. | 1. | 3. | 89. | 193. | 132. | 80. | 94. | 53. | 11. | 69. |
| | 50th% | 1. | 0. | 0. | 0. | 0. | 32. | 49. | 40. | 45. | 33. | 20. | 4. | 29. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 1. | 12. | 16. | 15. | 1. | 0. | 0. | 10. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 6. | 8. | 5. | 0. | 0. | 0. | 7. |
| Missouri River at North Dakota Border node 40 | | | | | | | | | | | | | | |
| | AVERAGE | 6397. | 6770. | 10829. | 11897. | 13048. | 12042. | 10146. | 8324. | 8797. | 11064. | 9181. | 8252. | 9717. |
| | 10th% | 11979. | 12775. | 11765. | 13516. | 14963. | 17579. | 16898. | 13104. | 14965. | 15776. | 13657. | 12598. | 13175. |
| | 20th% | 9242. | 10670. | 11451. | 12378. | 14507. | 14055. | 12823. | 11448. | 12685. | 14503. | 12886. | 11561. | 11909. |
| | 50th% | 4782. | 4907. | 10880. | 11824. | 13191. | 11336. | 8704. | 7910. | 8070. | 10356. | 9365. | 8270. | 9511. |
| | 80th% | 3411. | 3069. | 10208. | 11183. | 11932. | 9580. | 5570. | 4399. | 4526. | 7977. | 4709. | 4191. | 7193. |
| | 90th% | 3330. | 2989. | 9688. | 10948. | 10256. | 8076. | 4431. | 3643. | 3587. | 7118. | 3415. | 3446. | 6245. |
| Battle Creek at Mouth node A | | | | | | | | | | | | | | |
| | AVERAGE | 7. | 0. | 0. | 0. | 1. | 141. | 240. | 56. | 30. | 27. | 11. | 18. | 44. |
| | 10th% | 17. | 0. | 0. | 0. | 0. | 567. | 629. | 136. | 85. | 38. | 25. | 16. | 90. |
| | 20th% | 14. | 0. | 0. | 0. | 0. | 232. | 382. | 79. | 59. | 28. | 15. | 8. | 60. |
| | 50th% | 3. | 0. | 0. | 0. | 0. | 64. | 81. | 20. | 10. | 8. | 7. | 1. | 32. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 8. | 20. | 4. | 5. | 3. | 2. | 0. | 11. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 1. | 13. | 3. | 4. | 2. | 1. | 0. | 6. |

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milk River at Havre node B | | | | | | | | | | | | | | |
| | AVERAGE | 266. | 58. | 48. | 44. | 58. | 250. | 506. | 1070. | 1111. | 1109. | 915. | 471. | 495. |
| | 10th% | 343. | 119. | 102. | 81. | 127. | 588. | 996. | 1375. | 1383. | 1362. | 1237. | 747. | 629. |
| | 20th% | 326. | 70. | 62. | 45. | 67. | 393. | 640. | 1233. | 1316. | 1327. | 1172. | 657. | 587. |
| | 50th% | 277. | 41. | 31. | 26. | 34. | 122. | 386. | 1022. | 1134. | 1177. | 902. | 455. | 470. |
| | 80th% | 203. | 32. | 25. | 24. | 27. | 48. | 261. | 883. | 869. | 892. | 716. | 269. | 406. |
| | 90th% | 169. | 26. | 24. | 24. | 27. | 29. | 143. | 752. | 594. | 767. | 595. | 239. | 382. |
| Milk River near Harlem node C | | | | | | | | | | | | | | |
| | AVERAGE | 295. | 73. | 50. | 44. | 72. | 534. | 941. | 885. | 674. | 618. | 501. | 447. | 430. |
| | 10th% | 353. | 134. | 104. | 88. | 158. | 1339. | 2121. | 1389. | 785. | 766. | 731. | 562. | 650. |
| | 20th% | 342. | 95. | 63. | 45. | 105. | 913. | 1255. | 960. | 751. | 753. | 712. | 517. | 576. |
| | 50th% | 310. | 57. | 35. | 26. | 38. | 308. | 500. | 773. | 668. | 691. | 534. | 423. | 387. |
| | 80th% | 250. | 42. | 27. | 23. | 26. | 130. | 338. | 674. | 480. | 410. | 296. | 301. | 295. |
| | 90th% | 195. | 38. | 25. | 23. | 25. | 95. | 238. | 578. | 275. | 275. | 164. | 217. | 261. |
| Milk River near Dodson node D | | | | | | | | | | | | | | |
| | AVERAGE | 19. | 88. | 56. | 51. | 126. | 610. | 770. | 268. | 121. | 38. | 2. | 86. | 186. |
| | 10th% | 48. | 149. | 118. | 106. | 320. | 1588. | 2124. | 1211. | 318. | 0. | 0. | 125. | 467. |
| | 20th% | 24. | 118. | 73. | 67. | 141. | 1278. | 1240. | 356. | 0. | 0. | 0. | 0. | 319. |
| | 50th% | 0. | 73. | 39. | 29. | 58. | 395. | 175. | 0. | 0. | 0. | 0. | 0. | 131. |
| | 80th% | 0. | 54. | 29. | 23. | 28. | 44. | 0. | 0. | 0. | 0. | 0. | 0. | 47. |
| | 90th% | 0. | 43. | 25. | 23. | 25. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 23. |
| Milk River at Nashua node E | | | | | | | | | | | | | | |
| | AVERAGE | 228. | 179. | 101. | 85. | 206. | 1672. | 1902. | 765. | 515. | 426. | 417. | 422. | 578. |
| | 10th% | 276. | 245. | 176. | 146. | 488. | 4508. | 4971. | 2606. | 1339. | 912. | 616. | 443. | 1178. |
| | 20th% | 256. | 223. | 117. | 109. | 273. | 3051. | 3432. | 1016. | 644. | 435. | 530. | 341. | 744. |
| | 50th% | 222. | 168. | 86. | 60. | 119. | 1081. | 848. | 350. | 254. | 273. | 424. | 301. | 480. |
| | 80th% | 177. | 134. | 71. | 53. | 59. | 364. | 224. | 221. | 186. | 194. | 271. | 232. | 275. |
| | 90th% | 154. | 123. | 67. | 52. | 54. | 190. | 124. | 205. | 164. | 141. | 227. | 203. | 211. |
| Little Missouri River near Camp Crook, S.D. | | | | | | | | | | | | | | |
| | AVERAGE | 52.0 | 8.1 | 5.3 | 5.6 | 82.6 | 378.0 | 272.2 | 327.6 | 380.5 | 86.3 | 37.4 | 38.6 | 139.5 |
| | 10% | 93.8 | 11.4 | 8.9 | 11.5 | 331.0 | 937.8 | 827.8 | 1121.0 | 927.9 | 228.0 | 98.9 | 133.0 | 290.0 |
| | 20% | 22.7 | 8.6 | 7.6 | 6.1 | 40.0 | 615.0 | 512.0 | 715.5 | 606.3 | 120.0 | 70.0 | 54.0 | 205.1 |
| | 50% | 3.8 | 4.9 | 4.5 | 2.4 | 5.9 | 193.0 | 71.0 | 69.3 | 221.6 | 45.7 | 16.2 | 5.9 | 112.5 |
| | 80% | 2.4 | 2.8 | 2.5 | 1.2 | 2.3 | 34.3 | 25.1 | 15.8 | 20.9 | 14.9 | 3.6 | 2.2 | 49.3 |
| | 90% | 2.2 | 2.7 | 1.8 | 1.0 | 1.3 | 9.6 | 7.3 | 7.0 | 8.1 | 4.4 | 1.2 | 1.5 | 22.5 |
| Beaver Cr. near Trotters, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 1.1 | 2.5 | 1.1 | 2.1 | 32.2 | 215.9 | 94.9 | 15.8 | 40.8 | 33.0 | 3.5 | 0.6 | 37.0 |
| | 10% | 3.3 | 3.0 | 2.0 | 4.0 | 106.6 | 609.0 | 372.1 | 45.7 | 125.0 | 99.5 | 6.6 | 1.6 | 90.0 |
| | 20% | 2.4 | 1.8 | 1.5 | 1.2 | 34.5 | 446.9 | 109.3 | 19.9 | 57.6 | 25.3 | 2.9 | 0.9 | 66.9 |
| | 50% | 0.5 | 0.7 | 0.9 | 0.5 | 1.9 | 71.4 | 17.9 | 7.8 | 12.2 | 3.4 | 0.4 | 0.2 | 25.9 |
| | 80% | 0.0 | 0.0 | 0.2 | 0.0 | 0.4 | 13.9 | 6.8 | 1.8 | 2.9 | 0.6 | 0.0 | 0.1 | 6.0 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.6 | 3.4 | 0.9 | 1.0 | 0.1 | 0.0 | 0.0 | 3.4 |
| Little Beaver Cr. near Marmath, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 9.7 | 3.2 | 2.9 | 3.3 | 29.0 | 144.8 | 105.7 | 54.7 | 86.7 | 27.9 | 10.1 | 13.7 | 40.9 |
| | 10% | 14.7 | 6.8 | 6.3 | 7.4 | 113.0 | 502.1 | 311.2 | 222.0 | 220.0 | 72.9 | 33.3 | 52.9 | 106.6 |
| | 20% | 7.3 | 4.7 | 3.9 | 2.4 | 40.4 | 248.0 | 138.0 | 76.0 | 132.7 | 37.3 | 11.2 | 18.1 | 64.4 |
| | 50% | 2.2 | 2.7 | 2.2 | 0.7 | 3.9 | 56.5 | 25.4 | 16.1 | 52.9 | 15.6 | 5.2 | 2.5 | 29.1 |
| | 80% | 0.4 | 0.9 | 0.6 | 0.0 | 0.3 | 12.5 | 7.8 | 5.8 | 18.5 | 4.6 | 0.6 | 0.2 | 15.1 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.7 | 5.0 | 2.3 | 4.6 | 1.8 | 0.0 | 0.0 | 8.3 |
| Boxelder Cr. near Webster | | | | | | | | | | | | | | |
| | AVERAGE | 28.1 | 7.4 | 5.1 | 4.4 | 50.7 | 209.8 | 246.3 | 179.5 | 171.1 | 50.5 | 20.6 | 16.9 | 82.5 |
| | 10% | 37.7 | 11.1 | 8.6 | 8.7 | 195.0 | 573.0 | 725.0 | 582.0 | 397.2 | 122.0 | 53.4 | 43.5 | 178.3 |
| | 20% | 17.8 | 8.1 | 6.3 | 6.0 | 47.9 | 407.0 | 294.0 | 397.0 | 266.0 | 72.6 | 32.3 | 25.9 | 126.2 |
| | 50% | 5.3 | 6.1 | 4.5 | 2.9 | 5.2 | 100.1 | 55.7 | 43.7 | 114.9 | 32.0 | 11.8 | 7.6 | 63.6 |
| | 80% | 2.1 | 3.9 | 1.7 | 1.7 | 1.4 | 18.9 | 18.9 | 7.7 | 18.0 | 6.0 | 2.9 | 2.2 | 29.5 |
| | 90% | 1.2 | 2.6 | 0.9 | 1.6 | 0.9 | 11.7 | 13.1 | 3.9 | 6.3 | 3.1 | 1.3 | 0.9 | 17.3 |

**Table D-2. Differences between streamflows under existing conditions and the various alternatives**

**Consumptive Use Alternatives**

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Missouri River below Fort Peck Dam node 35 | | | | | | | | | | | | | | |
| | AVERAGE | -334. | -364. | 116. | -13. | -12. | -182. | -209. | -226. | -289. | -363. | -319. | -284. | -207. |
| | 10th% | 0. | 0. | 152. | 9. | 114. | -68. | 0. | 0. | 0. | -220. | 0. | 0. | -93. |
| | 20th% | 0. | 0. | 142. | 6. | 88. | -79. | 0. | -78. | 0. | -271. | -198. | -188. | -141. |
| | 50th% | -383. | -425. | 120. | 0. | 44. | -107. | -210. | -191. | -313. | -364. | -284. | -269. | -202. |
| | 80th% | -565. | -618. | 94. | -4. | -52. | -254. | -276. | -256. | -423. | -432. | -409. | -383. | -250. |
| | 90th% | -626. | -659. | 70. | -21. | -358. | -549. | -425. | -401. | -532. | -484. | -640. | -442. | -273. |
| Missouri River near Wolf Point node 36 | | | | | | | | | | | | | | |
| | AVERAGE | -296. | -352. | 123. | -9. | 0. | -208. | -170. | -202. | -334. | -398. | -280. | -244. | -198. |
| | 10th% | 49. | 18. | 168. | 17. | 140. | -46. | 106. | 41. | -5. | -151. | 16. | 11. | -108. |
| | 20th% | 27. | 6. | 151. | 10. | 99. | -69. | 2. | -17. | -41. | -281. | -164. | -115. | -145. |
| | 50th% | -336. | -415. | 125. | 2. | 46. | -126. | -153. | -187. | -363. | -392. | -254. | -254. | -186. |
| | 80th% | -508. | -601. | 98. | -2. | -51. | -309. | -296. | -277. | -470. | -483. | -403. | -344. | -225. |
| | 90th% | -592. | -652. | 72. | -20. | -357. | -614. | -478. | -399. | -551. | -527. | -531. | -429. | -262. |
| Redwater River near Vida node 37 | | | | | | | | | | | | | | |
| | AVERAGE | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 10th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 20th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 50th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| Poplar River near Poplar node 38 | | | | | | | | | | | | | | |
| | AVERAGE | 1. | 1. | 0. | 0. | 0. | 0. | 0. | -2. | -5. | -3. | -1. | -2. | -1. |
| | 10th% | 1. | 1. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 20th% | 1. | 1. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 50th% | 1. | 1. | 0. | 0. | 0. | 0. | 0. | -2. | -5. | 0. | 0. | -1. | -1. |
| | 80th% | 1. | 0. | 0. | 0. | 0. | 0. | 0. | -4. | -8. | -10. | -3. | -3. | -1. |
| | 90th% | 1. | 0. | 0. | 0. | 0. | 0. | 0. | -4. | -9. | -12. | -6. | -4. | -2. |
| Big Muddy Creek near Mouth, near Culbertson node 39 | | | | | | | | | | | | | | |
| | AVERAGE | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 10th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 20th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 50th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| Missouri River at North Dakota Border node 40 | | | | | | | | | | | | | | |
| | AVERAGE | -264. | -326. | 145. | 10. | 18. | -193. | -158. | -247. | -506. | -771. | -564. | -334. | -268. |
| | 10th% | 81. | 44. | 191. | 33. | 158. | -27. | 119. | 26. | -147. | -424. | -290. | -103. | -169. |
| | 20th% | 65. | 34. | 175. | 29. | 118. | -55. | 18. | -44. | -311. | -633. | -371. | -190. | -214. |
| | 50th% | -311. | -393. | 146. | 23. | 64. | -112. | -141. | -243. | -513. | -741. | -555. | -340. | -259. |
| | 80th% | -480. | -572. | 116. | 13. | -33. | -296. | -281. | -343. | -660. | -917. | -719. | -460. | -303. |
| | 90th% | -553. | -624. | 96. | -2. | -338. | -593. | -466. | -480. | -751. | -984. | -811. | -551. | -343. |
| Battle Creek at Mouth node A | | | | | | | | | | | | | | |
| | AVERAGE | 2. | 2. | 1. | 1. | 0. | -56. | -61. | -3. | 7. | 20. | 20. | 16. | -4. |
| | 10th% | 3. | 4. | 3. | 3. | 3. | 0. | 15. | 27. | 39. | 39. | 43. | 52. | 4. |
| | 20th% | 3. | 4. | 3. | 3. | 3. | -1. | 4. | 17. | 32. | 37. | 39. | 47. | 0. |
| | 50th% | 3. | 1. | 0. | 0. | 0. | -24. | -3. | 5. | 8. | 19. | 12. | 9. | -3. |
| | 80th% | -1. | 0. | 0. | 0. | 0. | -97. | -146. | -2. | -3. | 1. | 2. | 0. | -8. |
| | 90th% | -2. | 0. | 0. | 0. | 0. | -203. | -182. | -81. | -10. | 0. | 0. | 0. | -12. |

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milk River at Havre node B | | | | | | | | | | | | | | |
| | AVERAGE | 30. | 3. | 5. | 3. | 10. | 31. | 56. | 88. | 100. | 129. | 199. | 113. | 64. |
| | 10th% | 135. | 1. | 1. | 10. | 23. | 99. | 332. | 412. | 603. | 375. | 401. | 235. | 117. |
| | 20th% | 89. | 1. | 1. | 0. | 3. | 40. | 178. | 248. | 394. | 245. | 341. | 221. | 102. |
| | 50th% | 3. | 1. | 0. | 0. | 0. | 1. | 1. | 1. | 3. | 111. | 192. | 123. | 65. |
| | 80th% | -5. | 0. | 0. | 0. | 0. | 0. | -38. | -20. | -138. | -20. | 8. | -10. | 32. |
| | 90th% | -43. | 0. | 0. | 0. | 0. | 0. | -75. | -34. | -173. | -31. | -8. | -46. | 23. |
| Milk River near Harlem node C | | | | | | | | | | | | | | |
| | AVERAGE | 33. | 5. | 4. | 2. | 9. | -26. | -7. | 80. | 70. | 132. | 194. | 120. | 52. |
| | 10th% | 150. | 7. | 2. | 9. | 22. | 52. | 229. | 385. | 470. | 397. | 426. | 296. | 91. |
| | 20th% | 90. | 4. | 2. | 2. | 3. | 1. | 160. | 234. | 302. | 277. | 342. | 242. | 80. |
| | 50th% | 10. | 2. | -1. | -1. | 0. | -12. | -4. | 0. | -24. | 93. | 184. | 135. | 54. |
| | 80th% | -7. | -1. | -1. | -1. | -1. | -90. | -112. | -17. | -119. | 1. | 33. | -8. | 26. |
| | 90th% | -41. | -1. | -2. | -2. | -2. | -158. | -211. | -28. | -164. | 1. | 1. | -15. | 11. |
| Milk River near Dodson node D | | | | | | | | | | | | | | |
| | AVERAGE | 12. | 4. | 4. | 2. | 9. | -28. | 38. | 24. | -34. | 2. | 2. | 0. | 3. |
| | 10th% | 30. | 7. | 2. | 8. | 20. | 52. | 298. | 107. | 0. | 0. | 0. | 0. | 32. |
| | 20th% | 22. | 4. | 2. | 1. | 2. | 0. | 185. | 3. | 0. | 0. | 0. | 0. | 17. |
| | 50th% | 0. | 2. | -1. | -2. | 0. | -13. | 0. | 0. | 0. | 0. | 0. | 0. | 1. |
| | 80th% | 0. | -1. | -2. | -2. | -2. | -91. | -73. | 0. | -110. | 0. | 0. | -1. | -16. |
| | 90th% | 0. | -2. | -2. | -2. | -2. | -159. | -172. | -5. | -140. | 0. | 0. | -10. | -24. |
| Milk River at Nashua node E | | | | | | | | | | | | | | |
| | AVERAGE | 34. | 9. | 4. | 2. | 9. | -28. | 38. | 35. | -7. | 40. | 98. | 62. | 25. |
| | 10th% | 81. | 23. | 2. | 8. | 21. | 51. | 295. | 146. | 114. | 126. | 206. | 167. | 44. |
| | 20th% | 53. | 16. | 2. | 1. | 1. | 0. | 186. | 51. | 93. | 104. | 170. | 128. | 39. |
| | 50th% | 25. | 3. | -1. | -2. | 0. | -13. | 0. | -1. | -5. | 1. | 96. | 47. | 30. |
| | 80th% | 5. | -1. | -2. | -2. | -2. | -94. | -73. | -3. | -116. | -6. | 1. | -1. | 10. |
| | 90th% | 0. | -1. | -2. | -2. | -2. | -161. | -172. | -6. | -139. | -7. | -2. | -7. | -8. |
| Little Missouri River near Camp Crook, S.D. | | | | | | | | | | | | | | |
| | AVERAGE | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 | -3.1 | -0.7 | -0.9 | -4.1 | -4.4 | -2.9 | -1.5 | -1.4 |
| | 10% | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 | 0.5 | 0.3 | -1.3 | -2.2 | -1.2 | -0.6 | -0.9 |
| | 20% | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 | 0.5 | 0.3 | -2.2 | -3.1 | -1.9 | -0.9 | -1.2 |
| | 50% | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | -0.2 | -3.3 | -4.4 | -2.9 | -1.5 | -1.5 |
| | 80% | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | -6.7 | 0.0 | -1.5 | -5.7 | -5.4 | -3.8 | -2.1 | -1.8 |
| | 90% | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | -6.7 | -6.9 | -2.4 | -9.4 | -6.2 | -4.5 | -2.3 | -1.8 |
| Beaver Creek near Trotters, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -15.7 | -0.5 | -0.6 | -4.0 | -1.3 | 0.1 | 0.0 | -1.8 |
| | 10% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -1.2 | 1.9 | 0.8 | 0.2 | 0.8 | 0.7 | 0.1 | -0.9 |
| | 20% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -5.6 | 1.9 | 0.4 | 0.1 | 0.6 | 0.4 | 0.1 | -1.5 |
| | 50% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -21.0 | 1.5 | 0.1 | -2.3 | 0.1 | 0.1 | 0.0 | -2.1 |
| | 80% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -21.0 | -0.7 | -1.8 | -6.9 | -3.2 | 0.0 | 0.0 | -2.3 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -21.0 | -6.1 | -3.1 | -9.3 | -8.2 | 0.0 | 0.0 | -2.3 |
| Little Beaver Creek near Marmath, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -5.2 | -0.9 | -0.2 | -3.2 | -1.2 | -0.8 | -0.5 | -1.0 |
| | 10% | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.6 | -0.2 | -0.1 | 0.0 | 0.0 | -0.2 |
| | 20% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.1 | -0.4 | -0.5 | -0.3 | 0.0 | -0.9 |
| | 50% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -8.0 | 0.6 | 0.0 | -2.2 | -0.8 | -0.7 | -0.2 | -1.1 |
| | 80% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -9.4 | 0.0 | -0.1 | -4.8 | -1.2 | -0.9 | -0.4 | -1.3 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -9.4 | -9.3 | -0.5 | -11.9 | -2.5 | -1.1 | -1.3 | -1.3 |
| Boxelder Creek near Webster | | | | | | | | | | | | | | |
| | AVERAGE | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | -2.1 | -0.3 | -0.6 | -2.7 | -4.0 | -2.8 | -1.0 | -1.1 |
| | 10% | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.1 | -0.9 | -2.3 | -1.3 | -0.1 | -0.8 |
| | 20% | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.1 | -1.5 | -3.1 | -2.0 | -0.5 | -1.0 |
| | 50% | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.2 | -2.3 | -4.2 | -2.9 | -1.2 | -1.2 |
| | 80% | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | -4.4 | -0.1 | -0.7 | -3.8 | -4.7 | -3.9 | -1.6 | -1.3 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -4.4 | -4.6 | -1.8 | -6.5 | -5.0 | -4.1 | -1.8 | -1.4 |

### Combination Alternative

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Missouri River below Fort Peck Dam node 35 | | | | | | | | | | | | | | |
| | AVERAGE | -336. | -367. | 118. | -13. | -12. | -184. | -210. | -228. | -291. | -364. | -322. | -286. | -209. |
| | 10th% | 0. | 0. | 152. | 9. | 114. | -68. | 0. | 0. | 0. | -220. | 0. | 0. | -94. |
| | 20th% | 0. | 0. | 142. | 6. | 88. | -81. | 0. | -78. | 0. | -270. | -198. | -190. | -138. |
| | 50th% | -386. | -425. | 120. | 0. | 44. | -107. | -210. | -195. | -314. | -364. | -284. | -268. | -205. |
| | 80th% | -566. | -620. | 94. | -4. | -56. | -259. | -276. | -257. | -425. | -432. | -411. | -381. | -251. |
| | 90th% | -626. | -680. | 70. | -21. | -367. | -559. | -423. | -400. | -533. | -484. | -644. | -444. | -281. |
| Missouri River near Wolf Point node 36 | | | | | | | | | | | | | | |
| | AVERAGE | -300. | -358. | 123. | -10. | -2. | -155. | -122. | -190. | -326. | -388. | -280. | -244. | -188. |
| | 10th% | 48. | 16. | 168. | 15. | 131. | -5. | 185. | 87. | 6. | -181. | 27. | 15. | -87. |
| | 20th% | 28. | 3. | 148. | 9. | 96. | -64. | 27. | -2. | -34. | -276. | -177. | -129. | -129. |
| | 50th% | -379. | -421. | 122. | 2. | 46. | -105. | -75. | -177. | -349. | -380. | -245. | -247. | -183. |
| | 80th% | -516. | -603. | 95. | -4. | -54. | -258. | -270. | -260. | -483. | -470. | -401. | -320. | -218. |
| | 90th% | -592. | -662. | 72. | -19. | -365. | -557. | -396. | -403. | -548. | -514. | -538. | -426. | -248. |
| Redwater River near Vida node 37 | | | | | | | | | | | | | | |
| | AVERAGE | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 10th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 20th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 50th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| Poplar River near Poplar node 38 | | | | | | | | | | | | | | |
| | AVERAGE | 0. | 0. | 0. | 0. | 0. | 0. | 0. | -1. | -2. | -2. | -1. | -1. | -1. |
| | 10th% | 1. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 20th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 50th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | -1. | -2. | 0. | 0. | -1. | -1. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | -2. | -4. | -6. | -2. | -2. | -1. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | -2. | -4. | -7. | -4. | -3. | -1. |
| Big Muddy Creek near Mouth, near Culbertson node 39 | | | | | | | | | | | | | | |
| | AVERAGE | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 10th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 20th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 50th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| Missouri River at North Dakota Border node 40 | | | | | | | | | | | | | | |
| | AVERAGE | -288. | -348. | 131. | -3. | 4. | -150. | -118. | -214. | -413. | -575. | -425. | -294. | -226. |
| | 10th% | 60. | 26. | 177. | 21. | 137. | 1. | 189. | 78. | -84. | -286. | -151. | -46. | -121. |
| | 20th% | 41. | 14. | 157. | 16. | 104. | -57. | 33. | -6. | -182. | -437. | -277. | -165. | -169. |
| | 50th% | -370. | -412. | 130. | 9. | 55. | -100. | -73. | -206. | -432. | -550. | -404. | -292. | -222. |
| | 80th% | -505. | -593. | 103. | 3. | -48. | -253. | -268. | -298. | -567. | -684. | -545. | -389. | -254. |
| | 90th% | -577. | -650. | 80. | -12. | -358. | -549. | -391. | -409. | -672. | -745. | -700. | -492. | -285. |
| Battle Creek at Mouth node A | | | | | | | | | | | | | | |
| | AVERAGE | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 10th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 20th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 50th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milk River at Havre | | node B | | | | | | | | | | | | |
| | AVERAGE | 31. | 3. | 4. | 2. | 8. | 29. | 51. | 100. | 109. | 131. | 198. | 120. | 66. |
| | 10th% | 134. | 1. | 1. | 10. | 23. | 97. | 261. | 412. | 575. | 344. | 402. | 258. | 114. |
| | 20th% | 92. | 1. | 1. | 0. | 0. | 20. | 201. | 246. | 373. | 203. | 318. | 221. | 102. |
| | 50th% | 1. | 1. | 0. | 0. | 0. | 0. | 1. | 2. | 3. | 105. | 187. | 105. | 64. |
| | 80th% | 1. | 1. | 0. | 0. | 0. | 0. | -39. | 1. | -109. | 2. | 12. | 1. | 38. |
| | 90th% | -58. | 0. | 0. | 0. | 0. | 0. | -82. | -1. | -138. | 1. | 2. | -13. | 23. |
| Milk River near Harlem | | node C | | | | | | | | | | | | |
| | AVERAGE | 33. | 3. | 3. | 2. | 8. | 29. | 50. | 96. | 73. | 117. | 175. | 113. | 59. |
| | 10th% | 150. | 7. | 0. | 9. | 23. | 97. | 260. | 411. | 445. | 320. | 401. | 262. | 94. |
| | 20th% | 92. | 1. | 0. | 0. | 0. | 20. | 200. | 246. | 302. | 199. | 317. | 211. | 87. |
| | 50th% | 1. | 0. | 0. | 0. | 0. | 0. | 0. | 2. | 2. | 98. | 173. | 98. | 60. |
| | 80th% | 0. | 0. | -1. | 0. | -1. | -1. | -40. | 0. | -110. | 1. | 7. | -0. | 37. |
| | 90th% | -58. | -1. | -1. | -1. | -1. | -1. | -82. | -1. | -140. | 0. | 1. | -11. | 23. |
| Milk River near Dodson | | | node D | | | | | | | | | | | |
| | AVERAGE | 12. | 3. | 3. | 1. | 7. | 27. | 87. | 35. | -31. | 2. | 0. | 1. | 12. |
| | 10th% | 24. | 8. | 0. | 9. | 21. | 97. | 390. | 128. | 8. | 0. | 0. | 3. | 41. |
| | 20th% | 24. | 1. | 0. | -1. | 0. | 1. | 199. | 19. | 0. | 0. | 0. | 0. | 25. |
| | 50th% | 0. | 0. | -1. | -1. | -1. | -1. | 14. | 0. | 0. | 0. | 0. | 0. | 5. |
| | 80th% | 0. | -1. | -1. | -1. | -1. | -1. | -0. | 0. | -110. | 0. | 0. | 0. | 0. |
| | 90th% | 0. | -1. | -1. | -1. | -1. | -1. | -1. | -1. | -140. | 0. | 0. | -7. | -4. |
| Milk River at Nashua | | node E | | | | | | | | | | | | |
| | AVERAGE | 33. | 7. | 3. | 1. | 7. | 27. | 88. | 47. | -5. | 37. | 90. | 59. | 33. |
| | 10th% | 74. | 22. | 2. | 8. | 22. | 97. | 390. | 158. | 114. | 114. | 188. | 137. | 53. |
| | 20th% | 48. | 16. | 0. | 0. | 0. | 1. | 199. | 61. | 83. | 97. | 162. | 111. | 46. |
| | 50th% | 24. | 0. | -1. | -1. | -1. | -1. | 14. | 0. | -2. | 1. | 88. | 44. | 36. |
| | 80th% | 5. | -1. | -1. | -1. | -1. | -1. | -1. | -1. | -116. | -6. | 1. | 2. | 20. |
| | 90th% | 0. | -1. | -1. | -1. | -1. | -1. | -1. | -3. | -138. | -7. | -2. | -2. | 12. |
| Little Missouri River near Camp Crook, S.D. | | | | | | | | | | | | | | |
| | AVERAGE | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 | -3.0 | -0.7 | -0.9 | -4.1 | -4.4 | -2.9 | -1.5 | -1.4 |
| | 10% | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 | 0.5 | 0.3 | -1.3 | -2.2 | -1.2 | -0.6 | -0.9 |
| | 20% | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 | 0.5 | 0.3 | -2.2 | -3.1 | -1.9 | -0.9 | -1.2 |
| | 50% | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | -0.2 | -3.3 | -4.4 | -2.9 | -1.5 | -1.5 |
| | 80% | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | -6.6 | 0.0 | -1.5 | -5.9 | -5.4 | -3.8 | -2.1 | -1.8 |
| | 90% | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | -6.6 | -6.9 | -2.4 | -9.3 | -6.2 | -4.5 | -2.3 | -1.8 |
| Beaver Creek near Trotters, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -4.0 | 0.1 | -0.2 | -1.1 | -0.4 | 0.1 | 0.0 | -0.5 |
| | 10% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -1.3 | 0.4 | 0.1 | 0.0 | 0.2 | 0.2 | 0.0 | -0.4 |
| | 20% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -4.6 | 0.4 | 0.1 | 0.0 | 0.1 | 0.1 | 0.0 | -0.4 |
| | 50% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -4.6 | 0.4 | 0.1 | -0.8 | 0.0 | 0.0 | 0.0 | -0.5 |
| | 80% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -4.6 | 0.1 | -0.5 | -1.9 | -1.0 | 0.0 | 0.0 | -0.5 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -4.6 | -0.2 | -0.9 | -2.3 | -1.7 | 0.0 | 0.0 | -0.5 |
| Little Beaver Creek near Marmath, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -3.7 | -0.7 | -0.2 | -2.3 | -1.0 | -0.6 | -0.3 | -0.7 |
| | 10% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.5 | -0.1 | -0.2 | 0.0 | 0.0 | -0.2 |
| | 20% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | -0.3 | -0.4 | -0.3 | 0.0 | -0.6 |
| | 50% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -5.6 | 0.5 | 0.0 | -1.7 | -0.7 | -0.5 | -0.2 | -0.8 |
| | 80% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -6.6 | 0.0 | -0.1 | -3.4 | -1.0 | -0.7 | -0.3 | -0.9 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -6.6 | -6.8 | -0.4 | -8.4 | -2.0 | -0.8 | -0.4 | -0.9 |
| Boxelder Creek near Webster | | | | | | | | | | | | | | |
| | AVERAGE | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | -1.7 | -0.3 | -0.5 | -1.9 | -2.6 | -1.8 | -0.7 | -0.8 |
| | 10% | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.1 | -0.6 | -1.6 | -0.9 | 0.0 | -0.5 |
| | 20% | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.1 | -0.9 | -2.0 | -1.4 | -0.4 | -0.7 |
| | 50% | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | -1.6 | -2.6 | -1.9 | -0.7 | -0.8 |
| | 80% | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | -3.6 | -0.1 | -0.4 | -2.4 | -2.9 | -2.5 | -1.0 | -0.9 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -3.6 | -3.7 | -1.1 | -5.1 | -3.1 | -2.6 | -1.1 | -0.9 |

## Instream Alternative

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Missouri River below Fort Peck Dam node 35 | | | | | | | | | | | | | | |
| | AVERAGE | -336. | -367. | 118. | -13. | -12. | -184. | -210. | -228. | -291. | -364. | -322. | -286. | -209. |
| | 10th% | 0. | 0. | 152. | 9. | 114. | -68. | 0. | 0. | 0. | -220. | 0. | 0. | -94. |
| | 20th% | 0. | 0. | 142. | 6. | 88. | -81. | 0. | -78. | 0. | -270. | -198. | -190. | -138. |
| | 50th% | -386. | -425. | 120. | 0. | 44. | -107. | -210. | -195. | -314. | -364. | -284. | -268. | -205. |
| | 80th% | -567. | -620. | 94. | -4. | -56. | -259. | -276. | -257. | -426. | -432. | -411. | -382. | -251. |
| | 90th% | -626. | -680. | 70. | -21. | -367. | -559. | -423. | -400. | -534. | -484. | -644. | -444. | -281. |
| Missouri River near Wolf Point node 36 | | | | | | | | | | | | | | |
| | AVERAGE | -304. | -362. | 120. | -13. | -6. | -158. | -125. | -182. | -293. | -324. | -232. | -227. | -176. |
| | 10th% | 44. | 11. | 165. | 12. | 127. | -9. | 175. | 81. | 63. | -133. | 77. | 38. | -74. |
| | 20th% | 23. | -2. | 145. | 5. | 93. | -65. | 25. | 0. | -1. | -223. | -136. | -125. | -118. |
| | 50th% | -381. | -425. | 118. | -1. | 42. | -107. | -78. | -171. | -316. | -311. | -199. | -232. | -170. |
| | 80th% | -519. | -608. | 93. | -7. | -58. | -261. | -269. | -251. | -434. | -398. | -359. | -304. | -205. |
| | 90th% | -597. | -667. | 69. | -23. | -369. | -561. | -398. | -400. | -505. | -439. | -476. | -406. | -236. |
| Redwater River near Vida node 37 | | | | | | | | | | | | | | |
| | AVERAGE | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 10th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 20th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 50th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| Poplar River near Poplar node 38 | | | | | | | | | | | | | | |
| | AVERAGE | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 10th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 20th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 50th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| Big Muddy Creek near Mouth, near Culbertson node 39 | | | | | | | | | | | | | | |
| | AVERAGE | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 10th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 20th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 50th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| Missouri River at North Dakota Border node 40 | | | | | | | | | | | | | | |
| | AVERAGE | -304. | -362. | 120. | -14. | -6. | -159. | -126. | -183. | -297. | -330. | -237. | -229. | -178. |
| | 10th% | 44. | 11. | 165. | 11. | 128. | -9. | 175. | 81. | 63. | -134. | 76. | 38. | -74. |
| | 20th% | 22. | -2. | 146. | 5. | 93. | -65. | 24. | -1. | -2. | -224. | -137. | -125. | -124. |
| | 50th% | -382. | -426. | 118. | -1. | 42. | -107. | -78. | -172. | -319. | -312. | -200. | -236. | -172. |
| | 80th% | -520. | -609. | 93. | -7. | -58. | -261. | -270. | -252. | -436. | -402. | -360. | -305. | -206. |
| | 90th% | -597. | -667. | 68. | -23. | -370. | -561. | -399. | -401. | -535. | -456. | -476. | -419. | -237. |
| Battle Creek at Mouth node A | | | | | | | | | | | | | | |
| | AVERAGE | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 10th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 20th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 50th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milk River at Havre node B | | | | | | | | | | | | | | |
| | AVERAGE | 31. | 3. | 4. | 2. | 8. | 29. | 51. | 100. | 109. | 132. | 198. | 120. | 66. |
| | 10th% | 135. | 1. | 1. | 10. | 23. | 98. | 258. | 412. | 570. | 343. | 404. | 246. | 114. |
| | 20th% | 93. | 1. | 1. | 0. | 0. | 20. | 196. | 244. | 370. | 203. | 315. | 221. | 101. |
| | 50th% | 2. | 1. | 0. | 0. | 0. | 0. | 2. | 3. | 4. | 106. | 187. | 106. | 64. |
| | 80th% | 1. | 0. | 0. | 0. | 0. | 0. | -39. | 2. | -108. | 3. | 11. | 2. | 38. |
| | 90th% | -56. | 0. | 0. | 0. | 0. | 0. | -76. | -1. | -137. | 3. | 3. | -12. | 24. |
| Milk River near Harlem node C | | | | | | | | | | | | | | |
| | AVERAGE | 33. | 2. | 2. | 1. | 7. | 28. | 49. | 95. | 72. | 115. | 173. | 112. | 58. |
| | 10th% | 150. | 6. | -1. | 8. | 22. | 96. | 257. | 410. | 440. | 317. | 401. | 261. | 93. |
| | 20th% | 92. | 0. | -1. | -1. | -1. | 19. | 194. | 242. | 297. | 195. | 313. | 210. | 85. |
| | 50th% | 1. | -1. | -1. | -1. | -1. | -1. | 0. | 1. | 1. | 98. | 171. | 98. | 59. |
| | 80th% | -1. | -1. | -2. | -1. | -2. | -2. | -41. | 0. | -110. | 1. | 6. | -0. | 36. |
| | 90th% | -58. | -2. | -2. | -2. | -2. | -2. | -78. | -3. | -140. | 0. | 1. | -11. | 23. |
| Milk River near Dodson node D | | | | | | | | | | | | | | |
| | AVERAGE | 12. | 2. | 2. | 0. | 6. | 26. | 85. | 34. | -32. | 2. | 0. | 0. | 11. |
| | 10th% | 24. | 7. | -1. | 8. | 20. | 96. | 379. | 126. | 7. | 0. | 0. | 2. | 40. |
| | 20th% | 24. | 0. | -1. | -2. | -1. | 1. | 195. | 18. | 0. | 0. | 0. | 0. | 25. |
| | 50th% | 0. | -1. | -2. | -2. | -2. | -2. | 13. | 0. | 0. | 0. | 0. | 0. | 5. |
| | 80th% | 0. | -2. | -2. | -2. | -2. | -2. | -2. | 0. | -110. | 0. | 0. | 0. | -1. |
| | 90th% | 0. | -2. | -2. | -2. | -2. | -2. | -3. | -3. | -140. | 0. | 0. | -7. | -4. |
| Milk River at Nashua node E | | | | | | | | | | | | | | |
| | AVERAGE | 33. | 6. | 2. | 0. | 6. | 26. | 86. | 47. | -1. | 42. | 92. | 60. | 33. |
| | 10th% | 73. | 21. | 1. | 7. | 21. | 96. | 379. | 160. | 116. | 117. | 192. | 138. | 53. |
| | 20th% | 48. | 15. | -1. | -2. | -1. | 1. | 196. | 62. | 86. | 100. | 165. | 113. | 45. |
| | 50th% | 23. | -1. | -2. | -2. | -2. | -2. | 13. | 0. | 0. | 5. | 92. | 46. | 36. |
| | 80th% | 4. | -2. | -2. | -2. | -2. | -2. | -2. | 0. | -111. | 0. | 0. | 2. | 20. |
| | 90th% | 0. | -2. | -2. | -2. | -2. | -2. | -3. | -2. | -131. | 0. | 0. | 0. | 12. |
| Little Missouri River near Camp Crook, S.D. | | | | | | | | | | | | | | |
| | AVERAGE | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.2 | -1.2 | -2.3 | -1.2 | -0.3 | -0.4 |
| | 10% | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.2 | 0.0 | 0.1 | 0.1 | -0.2 |
| | 20% | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.7 | -1.5 | 0.1 | 0.1 | -0.3 |
| | 50% | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -1.1 | -2.6 | -1.5 | 0.0 | -0.4 |
| | 80% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.3 | -1.7 | -3.0 | -2.1 | -0.8 | -0.5 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.6 | -2.2 | -3.3 | -2.3 | -1.2 | -0.6 |
| Beaver Creek near Trotters, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -4.0 | 0.1 | -0.2 | -1.1 | -0.4 | 0.1 | 0.0 | -0.5 |
| | 10% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -1.3 | 0.4 | 0.1 | 0.0 | 0.2 | 0.2 | 0.0 | -0.4 |
| | 20% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -4.6 | 0.4 | 0.1 | 0.0 | 0.1 | 0.1 | 0.0 | -0.4 |
| | 50% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -4.6 | 0.4 | 0.1 | -0.8 | 0.0 | 0.0 | 0.0 | -0.5 |
| | 80% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -4.6 | 0.1 | -0.5 | -1.9 | -1.0 | 0.0 | 0.0 | -0.5 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -4.6 | -0.2 | -0.9 | -2.3 | -1.7 | 0.0 | 0.0 | -0.5 |
| Little Beaver Creek near Marmath, N.D. | | | | | | | | | | | | | | |
| | AVERAGE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.3 | -0.6 | -0.3 | -0.1 | -0.1 |
| | 10% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 20% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.2 | -0.4 | 0.0 | 0.0 | -0.1 |
| | 50% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.2 | -0.7 | -0.4 | 0.0 | -0.1 |
| | 80% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | -0.4 | -0.8 | -0.6 | -0.2 | -0.1 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | -0.5 | -0.9 | -0.7 | -0.2 | -0.2 |
| Boxelder Creek near Webster | | | | | | | | | | | | | | |
| | AVERAGE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | -0.5 | -1.2 | -0.7 | -0.1 | -0.2 |
| | 10% | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | -0.1 |
| | 20% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.3 | 0.0 | 0.1 | 0.1 | -0.1 |
| | 50% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.5 | -1.4 | -0.9 | 0.0 | -0.2 |
| | 80% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.2 | -0.9 | -1.7 | -1.3 | -0.4 | -0.3 |
| | 90% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.3 | -1.0 | -1.8 | -1.4 | -0.5 | -0.3 |

## No Action Alternative

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Missouri River below Fort Peck Dam node 35 | | | | | | | | | | | | | | |
| | AVERAGE | -311. | -337. | 118. | 3. | 1. | -168. | -190. | -206. | -268. | -355. | -298. | -264. | -190. |
| | 10th% | 0. | 0. | 149. | 12. | 113. | -61. | 0. | 0. | 0. | -217. | 0. | 0. | -85. |
| | 20th% | 0. | 0. | 141. | 8. | 97. | -70. | 0. | -67. | 0. | -267. | -189. | -168. | -129. |
| | 50th% | -354. | -389. | 117. | 4. | 47. | -96. | -187. | -169. | -286. | -355. | -257. | -245. | -185. |
| | 80th% | -523. | -570. | 95. | 1. | -47. | -244. | -248. | -231. | -388. | -431. | -366. | -349. | -226. |
| | 90th% | -568. | -614. | 72. | -5. | -324. | -502. | -377. | -362. | -499. | -479. | -614. | -420. | -251. |
| Missouri River near Wolf Point node 36 | | | | | | | | | | | | | | |
| | AVERAGE | -277. | -330. | 121. | 5. | 9. | -140. | -99. | -158. | -268. | -312. | -204. | -203. | -155. |
| | 10th% | 43. | 13. | 158. | 15. | 121. | 3. | 225. | 96. | 63. | -124. | 80. | 38. | -64. |
| | 20th% | 23. | 1. | 149. | 10. | 101. | -54. | 25. | 0. | -1. | -222. | -98. | -100. | -96. |
| | 50th% | -354. | -378. | 117. | 4. | 50. | -95. | -51. | -152. | -289. | -306. | -174. | -206. | -148. |
| | 80th% | -476. | -554. | 96. | 0. | -47. | -245. | -248. | -228. | -409. | -388. | -285. | -281. | -184. |
| | 90th% | -529. | -590. | 72. | -15. | -324. | -503. | -371. | -363. | -467. | -423. | -444. | -361. | -204. |
| Redwater River near Vida node 37 | | | | | | | | | | | | | | |
| | AVERAGE | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 10th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 20th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 50th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| Poplar River near Poplar node 38 | | | | | | | | | | | | | | |
| | AVERAGE | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 10th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 20th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 50th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| Big Muddy Creek near Mouth, near Culbertson node 39 | | | | | | | | | | | | | | |
| | AVERAGE | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 10th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 20th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 50th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| Missouri River at North Dakota Border node 40 | | | | | | | | | | | | | | |
| | AVERAGE | -278. | -330. | 121. | 4. | 8. | -140. | -100. | -159. | -269. | -313. | -205. | -204. | -156. |
| | 10th% | 43. | 13. | 158. | 15. | 121. | 3. | 225. | 95. | 62. | -125. | 79. | 38. | -65. |
| | 20th% | 23. | 0. | 148. | 9. | 100. | -54. | 24. | -1. | -2. | -223. | -99. | -100. | -97. |
| | 50th% | -355. | -379. | 117. | 4. | 50. | -95. | -52. | -153. | -290. | -306. | -175. | -206. | -149. |
| | 80th% | -477. | -555. | 96. | 0. | -47. | -245. | -249. | -229. | -410. | -389. | -286. | -281. | -185. |
| | 90th% | -529. | -590. | 71. | -16. | -325. | -503. | -372. | -363. | -468. | -424. | -445. | -361. | -204. |
| Battle Creek at Mouth node A | | | | | | | | | | | | | | |
| | AVERAGE | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 10th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 20th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 50th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |

| Model | % Flow | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milk River at Havre | node B | | | | | | | | | | | | | |
| | AVERAGE | 29. | 3. | 4. | 2. | 8. | 30. | 52. | 99. | 109. | 132. | 199. | 121. | 66. |
| | 10th% | 133. | 1. | 1. | 10. | 23. | 97. | 267. | 412. | 582. | 347. | 401. | 274. | 115. |
| | 20th% | 91. | 1. | 1. | 0. | 1. | 20. | 203. | 250. | 379. | 204. | 323. | 221. | 102. |
| | 50th% | 1. | 1. | 0. | 0. | 0. | 0. | 0. | 2. | 4. | 105. | 188. | 104. | 65. |
| | 80th% | -0. | 1. | 0. | 0. | 0. | 0. | -39. | 0. | -111. | 0. | 15. | -0. | 38. |
| | 90th% | -60. | 0. | 0. | 0. | 0. | 0. | -86. | 0. | -140. | 0. | 0. | -15. | 23. |
| Milk River near Harlem | node C | | | | | | | | | | | | | |
| | AVERAGE | 32. | 4. | 4. | 2. | 8. | 30. | 52. | 96. | 74. | 118. | 176. | 113. | 60. |
| | 10th% | 150. | 8. | 1. | 10. | 23. | 97. | 267. | 412. | 452. | 323. | 400. | 264. | 95. |
| | 20th% | 92. | 2. | 0. | 0. | 1. | 20. | 202. | 251. | 309. | 205. | 323. | 212. | 87. |
| | 50th% | 1. | 1. | 0. | 0. | 0. | 0. | 0. | 3. | 3. | 98. | 175. | 104. | 61. |
| | 80th% | -0. | 0. | 0. | 0. | 0. | 0. | -39. | 0. | -110. | 0. | 9. | -0. | 38. |
| | 90th% | -60. | 0. | 0. | 0. | 0. | 0. | -85. | 0. | -140. | 0. | 0. | -12. | 23. |
| Milk River near Dodson | node D | | | | | | | | | | | | | |
| | AVERAGE | 12. | 4. | 4. | 2. | 8. | 29. | 91. | 36. | -31. | 2. | 1. | 1. | 13. |
| | 10th% | 24. | 9. | 1. | 10. | 22. | 98. | 405. | 129. | 10. | 0. | 0. | 5. | 42. |
| | 20th% | 23. | 2. | 1. | 0. | 1. | 2. | 201. | 21. | 0. | 0. | 0. | 0. | 26. |
| | 50th% | 0. | 1. | 0. | 0. | 0. | 0. | 20. | 0. | 0. | 0. | 0. | 0. | 6. |
| | 80th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | -110. | 0. | 0. | 0. | 0. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | -140. | 0. | 0. | -7. | -4. |
| Milk River at Nashua | node E | | | | | | | | | | | | | |
| | AVERAGE | 33. | 8. | 4. | 2. | 8. | 29. | 91. | 48. | 0. | 43. | 94. | 62. | 35. |
| | 10th% | 76. | 24. | 3. | 9. | 22. | 98. | 405. | 160. | 116. | 122. | 196. | 140. | 55. |
| | 20th% | 48. | 17. | 0. | 0. | 0. | 1. | 201. | 62. | 91. | 104. | 167. | 116. | 48. |
| | 50th% | 24. | 1. | 0. | 0. | 0. | 0. | 20. | 0. | 0. | 4. | 92. | 47. | 38. |
| | 80th% | 5. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | -111. | 0. | 0. | 3. | 19. |
| | 90th% | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | -131. | 0. | 0. | 0. | 14. |

# APPENDIX E

## WATER QUALITY INFORMATION FOR LOWER MISSOURI RIVER BASIN STREAMS

**Table E-1. Water Quality Classifications for lower Missouri River Basin streams**

| | |
|---|---|
| Lower Missouri River Subbasin and Sheridan County Groundwater Area | |
| Missouri River from Fort Peck Dam to mouth of Milk River | B-2 |
| Missouri River from mouth of Milk River to North Dakota boundary | B-3 |
| Streams in the Wolf Creek drainage | B-2 |
| Streams in the Antelope Creek drainage | B-3 |
| Streams in the Poplar River drainage | B-2 |
| All other streams | C-3 |
| Milk River Subbasin | |
| Streams in the Milk River drainage from Glacier Park to International boundary | B-1 |
| Streams in the Big Sandy Creek drainage | B-1 |
| Streams in the Beaver, Little Box Elder and Clear Creek drainages (near Havre) | B-1 |
| Streams in the Peoples Creek drainage to and including the South Fork of Peoples Creek | B-1 |
| All other streams | B-3 |
| Little Missouri River Subbasin | |
| All streams | C-3 |

Source: 16.20.607 and 16.20.609 ARM

**Table E-2. Summary of water quality data for selected stations in the Milk River Subbasin[a]**

| Station[b] | Discharge[c] (cfs) | Basin Area (sq.mi.) | Water Temp. (C_) | pH | Suspended—Sediment (mg/l) | Turbidity (NTU)[d] | Dissolved—Oxygen mg/l | Specific Conductance (uS/cm)[e] | Dissolved Solids (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| Milk River | 430 | 5,785 | 0—23.5 | 6.9—8.5 | | | | 244—1,040 | 135—456 |
| (at Havre, MT—140500 | | | (134) | (23) | | | | (126) | (20) |
| Milk River | 394 | 17,670 | 0—27.0 | 7.3—8.7 | | | | 0—2,020 | 210—1,370 |
| (near Saco, MT—164510) | | | (155) | (29) | | | | (154) | (55) |
| Milk River | 390 | 21,078 | 0—25.5 | 7.3—8.1 | | | | 337—2,250 | 195—1,360 |
| (at Tampico, MT—172310) | | | (84) | (3) | | | | (77) | (36) |
| Milk River | 542 | 22,332 | 0—30.0 | 6.7—8.7 | 6—7,740 | 0.8—5,000 | 5.1—15.0 | 0—2,460 | 218—1,810 |
| (at Nashua, MT—174500) | | | (313) | (297) | (149) | (94) | (242) | (326) | (100) |
| Beaver Creek | | | 0—17 | 7.5—8.3 | | | | 171—305 | 104—173 |
| (near Rocky Boy, MT—139900) | | | (75) | (11) | | | | (77) | (3) |
| Little Box Elder Creek | | 95.9 | 0—23 | | | | | 503—1,790 | |
| (near Havre, MT—141600) | | | (46) | | | | | (46) | |
| Battle Creek | 44 | 1,539 | 0—27 | | | | | 253—2,030 | |
| (near Chinook, MT—151500) | (.2—902) | | (56) | | | | | (57) | |
| Battle Creek | | 997 | 0—28 | 6.8—9.1 | | | | 140—1,460 | 447—735 |
| (at Int. Boundary —149500) | (0—9,780) | | (67) | (9) | | | | (65) | (5) |
| Little Peoples Creek | 4.6 | 13 | 0—18 | 7.4—8.5 | 1—287 | 0—455 | 8.2—12.1 | 300—638 | 177—289 |
| (near Hays, MT—154410) | (0.92—76) | | (128) | (70) | (65) | (24) | (72) | (126) | (42) |
| Peoples Creek | 31.4 | 675 | 0—27 | 8.0—8.5 | | | | 0—1,850 | |
| (near Dodson, MT—154550) | (0—7,590) | | (30) | (14) | | | | (30) | |
| Beaver Creek | 1.1 | 10.1 | 0—22 | 8.0—8.2 | | | | 234—700 | |
| (near Zortman, MT—166000) | | | | (68) | (4) | | | | (68) |
| Frenchman River | | 2,120 | | | | | | | |
| (at Int.Boundary—164000) | (0—22,700) | | | | | | | | |
| Rock Creek | 14.7 | 328 | 0—24.5 | 6.9—9.3 | 14—544 | 0.8—280 | 1.1—16.6 | 0—2,380 | 67—1,360 |
| (near Int. Boundary—169500) | (0—4,420) | | (139) | (99) | (80) | (32) | (94) | (141) | (44) |
| Porcupine Creek | 20.0 | 725 | 0—24 | 7.5—8.4 | | | | 150—3,520 | 126—1,050 |
| (at Nashua, MT—175000) | (0—6,600) | (37) | (23) | | | | (37) | (4) | |

Table E-2. Summary of water quality data for selected stations in the Milk River Subbasin[a] (cont.)

| Station | Sulfate (mg/l) | Alkalinity (mg/l as CaCo$_3$) | Bicarbonate (mg/l) | Sodium Adsorption Ratio (SAR) | Dissolved Boron (_g/L) | Total Selenium (_g/L) | Total Arsenic (_g/L) | Nitrate—Nitrogen (mg/l) | Total Phosphorous (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| Milk River | 23—160 | 102—217 | 124—264 | 0.5—2.9 | 20—124 | | | 0.1—0.3 | |
| (at Havre, MT—140500) | (23) | (23) | (23) | (23) | (23) | | | (7) | |
| Milk River | 60—650 | 98—400 | 120—490 | 1.5—5.1 | | | | 0—1.7 | |
| (near Saco, MT—164510) | (143) | (34) | (11) | (55) | | | | (140) | |
| Milk River | 76—610 | 67—409 | 82—499 | 1.8—5.1 | 90—130 | | | 0.01—0.5[g] | |
| (at Tampico, MT—172310) | (36) | (36) | (36) | (36) | (3) | | | (33) | |
| Milk River | 72—860 | 36—480 | 0—590 | 1.5—6.4 | 70—460 | 0—10 | 1—42 | 0—0.96 | 0.010—2.7 |
| (at Nashua, MT)—174500) | (204) | (158) | (116) | (145) | (63) | (27) | (26) | (77) | (129) |
| Beaver Creek | 6—24 | | | 0.4—0.5 | 20—40 | 1—1 | 1—1 | 0.1—0.7 | |
| (near Rocky Boy, MT—139900) | (11) | | | (3) | (11) | (3) | (3) | (11) | |
| Little Box Elder Creek | | | | | | | | | |
| (near Havre, MT—141600) | | | | | | | | | |
| Battle Creek | | | | | | | | | |
| (near Chinook, MT—151500) | | | | | | | | | |
| Battle Creek | 20—380 | 59—260 | 72—317 | 0.4—3.2 | 30—90 | 1—1[f] | 1—8[g] | 0.01—0.2 | 0.01—0.049[g] |
| (at Int. Boundary—149500) | (18) | (8) | (9) | (9) | 12 | (9) | (9) | (14) | (5) |
| Little Peoples Creek | 22—55 | 140—236 | 200—281 | 0.1—0.1 | 0—70 | 1—2 | 1—11 | 0—0.37 | 0—0.290 |
| (near Hays, MT—154410) | (80) | (43) | (24) | (42) | (80) | (54) | (54) | (75) | (68) |
| Peoples Creek | 160—660 | | | | 170—590 | 1—2 | 1—2[g] | 0.05—0.1[g] | |
| (near Dodson, MT—154550) | (14) | | | | (14) | (4) | (4) | (14) | |
| Beaver Creek | 24—57 | | | | 20—50 | 1[f] | 1[g] | 0.1—0.1[g] | |
| (near Zortman, MT—166000) | (4) | | | | (4) | (1) | (1) | (4) | |
| Frenchman River | | | | | | | | | |
| (at Int.Boundary—164000) | | | | | | | | | |
| Rock Creek | 7—590 | 0—820 | 0—580 | 1—13 | 60—410 | 0—1 | 1—7 | 0—0.41 | 0.010—0.43 |
| (near Int. Boundary—169500) | (79) | (69) | (11) | (48) | (7) | (9) | (9) | (46) | (75) |
| Porcupine Creek | 45—1,600 | | | 1.6—5.6 | 60—560 | 1-1 | 1-3 | 0.1—2.3 | |
| (at Nashua, MT—175000) | (23) | | | (4) | (23) | (6) | (6) | (23) | |

**Table E-3. Summary of Water Quality Data for Selected Stations in the Lower Missouri River Subbasin[a]**

| Station[b] | Discharge[c] (cfs) | Basin Area (sq.mi.) | Water Temp. (C_) | pH | Suspended—Sediment (mg/l) | Turbidity (NTU)[d] | Dissolved—Oxygen mg/l | Specific Conductance (uS/cm)[e] | Dissolved Solids (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| West Fk. Poplar River | | | 0—30.0 | 7.2—9.2 | 9—347 | 1.0—170.0 | 2.2—14.4 | 0—2,150 | 89—1,440 |
| (nr. Bredette, MT—180400) | | | (126) | (81) | (67) | (56) | (82) | (126) | (67) |
| Poplar River | | 358 | 0—28.0 | 7.5—9.2 | 1—238 | 0.7—190 | 4.6—14.0 | 170—2,600 | 87—1,900 |
| (at Intl. Boundary—178000) | | | (182) | (148) | (130) | (119) | (148) | (183) | (66) |
| East Poplar River | 7.4 | 541 | 0—26.0 | 7.1—9.1 | 4—322 | 0.5 — 55.0 | 0.9—14.6 | 0—2,300 | 97—1,480 |
| (at Intl. Bdry.—178500) | | | (223) | (203) | (172) | (156) | (201) | (224) | (91) |
| East Fk. Poplar River | | 722 | 0—25.0 | 7.5—9.9 | 4—492 | 0.5—75.0 | 0.2—14.0 | 0—3,100 | 104—2,300 |
| (nr. Scobey, MT—179000) | | | (176) | (166) | (147) | (138) | (165) | (169) | (76) |
| Poplar River | | 1,745 | 0—26.5 | 7.4—9.3 | 7—297 | 0.5—110 | 6.2—12.9 | 0—2,700 | 172—1,900 |
| (near Bredette, MT—179200) | | | (127) | (58) | (46) | (31) | (57) | (129) | (58) |
| Poplar River | 124 | 3,174 | 0—26 | 7.4—9.3 | 2—1,270 | 0.9—550 | 2.7—13.6 | 0—3,730 | 167—1,930 |
| (nr. Poplar, MT—181000) | | | (202) | (145) | (120) | (69) | (145) | (202) | (66) |
| Redwater River | 12.5 | 547 | 0—29 | 7.2—9.7 | 2—1,300 | 0—460[f] | 1.0—13.6 | 336—6,400 | 216—4,470 |
| (at Circle, MT—177500) | | | (160) | (103) | (97) | (45) | (102) | (159) | (84) |
| Redwater River 0—28 | | 1,974 | 0—28 | 7.3—9.3 | 1—1,700 | 3—1,000[f] | 4.2—12.7 | 430—5,000 | 240—3,490 |
| (near Vida, MT—177825) | | | (105) | (93) | (92) | (33) | (92) | (106) | (76) |
| Big Muddy Creek | 29.8 | 967 | 0—27 | 7.3—10.1 | 5—616 | 1.5—230 | 0—17.1 | 0—6,000 | 120—3,700 |
| (near Antelope, MT—183450) | | | (137) | (79) | (77) | (29) | (81) | (136) | (35) |
| Big Muddy Creek | 24.4 | 2,684 | 0—29 | 7.7—9.1 | | | | 379—10,500 | 251—1,440 |
| (near mouth—185110) | | | (59) | (29) | | | | (59) | (4) |
| Missouri River | 9,770 | 57,556 | 0—18.0 | 7.5—8.8 | 2—99 | 0.4—13.0 | 8.2—14.3 | 542—850 | 342—547 |
| (below Ft. Peck Dam — 13200) | | | (155) | (135) | (73) | (60) | (152) | (138) | (58) |
| Missouri River | 10,400 | 82,290 | 0—20.6 | 7.0—8.4 | | | | 525—1,150 | 367—447 |
| (near Wolf Point, MT—177000) | | | (98) | (90) | | | | (130) | (54) |
| Missouri River | 10,570 | 91,557 | 0—23 | 7.2—9.0 | 19—2,370 | 0.9—370 | 6.8—14.2 | 386—1,000 | 244—579 |
| (near Culbertson, MT—185500) | | | (281) | (203) | (98) | (55) | (167) | (225) | (100) |

Table E-3. Summary of Water Quality Data for Selected Stations in the Lower Missouri River Subbasin[a] (cont.)

| Station | Sulfate (mg/l) | Alkalinity (mg/l as CaCo$_3$) | Bicarbonate (mg/l) | Sodium Adsorption Ratio (SAR) | Dissolved Boron (_g/L) | Total Selenium (_g/L) | Total Arsenic (_g/L) | Nitrate—Nitrogen (mg/l) | Total Phosphorous (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| West Fk. Poplar River | 7—380 | 71—853 | 110—1,040 | 1—21 | 50—1,900 | 0—2 | 1—5 | 0.01—.99 | 0.010—0.390 |
| (nr. Bredette, MT—180400) | (112) | (65) | (27) | (67) | (112) | (14) | (14) | (31) | (83) |
| Poplar River | 8—710 | 61—810 | 110—790 | 0.6—12 | 80—2,400 | 0—2.0 | 1—10 | 0—4.4 | 0.010—0.410 |
| (at Intl. Boundary—178000) | (150) | (71) | (27) | (68) | (122) | (21) | (21) | (148) | (147) |
| East Poplar River | 20—500 | 0—762 | 73—929 | 0.7—9.4 | 120—3,100 | 1—1 | 1—14 | 0—0.69 | 0.010—0.4 |
| (at Intl. Bdry.—178500) | (208) | (102) | (47) | (94) | (147) | (28) | (28) | (206) | (206) |
| East Fk. Poplar River | 18—690 | 71—1,280 | 86—1,560 | 0.6—11.0 | 110—3,700 | 0—1 | 2—8 | 0—1.7 | 0.010—0.770 |
| (nr. Scobey, MT—179000) | (175) | (86) | (34) | (76) | (127) | (19) | (19) | (167) | (167) |
| Poplar River | 25—570 | 110—1,020 | 130—1,240 | 1.1—13.0 | 220—2,400 | 0—4 | 2—5 | 0—1.1 | 0—0.410 |
| (near Bredette, MT—179200) | (87) | (58) | (27) | (58) | (68) | (10) | (10) | (58) | (58) |
| Poplar River | 0—410 | 110—718 | 130—840 | 1.4—16.0 | 150—1,600 | 0—3 | 1—5 | 0—.77 | 0—0.55 |
| (nr. Poplar, MT—181000) | (103) | (102) | (33) | (66) | (64) | (10) | (10) | (78) | (102) |
| Redwater River | 91—2,700 | 82—927 | 100—1,130 | .9—17.0 | 110—970 | 0—1 | 1—6 | 0—0.73 | 0.010—0.610 |
| (at Circle, MT—177500) | (103) | (89) | (44) | (86) | (103) | (21) | (21) | (103) | (103) |
| Redwater River | 110—2,000 | 98—850 | 120—1,020 | 2—19 | 80—630 | 0—8 | 1—35 | 0—1.2 | 0.010—0.720 |
| (near Vida, MT—177825) | (93) | (81) | (33) | (76) | (93) | (19) | (19) | (91) | (92) |
| Big Muddy Creek | 29—2,100 | 62—1,760 |  | 0.9—15.0 | 60—3,700 | 0—1 | 2—22 | 0—0.92 | 0.020—2.9 |
| (near Antelope, MT—183450) | (101) | (46) |  | (37) | (81) | (14) | (14) | (80) | (80) |
| Big Muddy Creek | 88—2,100 |  |  | 1.7—9.4 | 110—920 | 1—2 | 2—124 | 0.1—2.9 |  |
| (near mouth—185110) | (29) |  |  | (4) | (36) | (7) | (7) | (29) |  |
| Missouri River | 120—270 | 114—171 | 0—200 | 1.1—2.2 |  | 1—2 | 2—6 | 0—0.39 | 0—0.070 |
| (below Ft. Peck Dam — 13200) | (87) | (69) | (26) | (58) |  | (17) | (18) | (58) | (88) |
| Missouri River | 127—180 | 137—173 | 167—211 | 1.1—1.8 | 0—160 |  |  |  | 0.16 |
| (near Wolf Point, MT—177000) | (90) | (76) | (90) | (90) | (68) |  |  |  | (1) |
| Missouri River | 99—290 | 90—231 | 0—218 | 1.1—2.1 | 20—150 | 1—2 | 2—14 | 0—2.2 | 0—0.910 |
| (near Culbertson, MT—185500) | (135) | (130) | (78) | (104) | (24) | (17) | (17) | (55) | (111) |

**Table E-4. Summary of Water Quality Data for Selected Stations in the Little Missouri Basin[a]**

| Station[b] | Discharge[c] (cfs) | Basin Area (sq.mi.) | Water Temp. (C_) | pH | Suspended—Sediment (mg/l) | Turbidity (NTU)[d] | Dissolved—Oxygen mg/l | Specific Conductance (uS/cm)[e] | Dissolved Solids (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| Beaver Creek | | 351 | 0—27 | 7.6—9.2 | | | 5.2—11.6 | 498—3,320 | 539—2,400 |
| (at Wibaux, MT—336500) | (0.01—653) | | (57) | (56) | | | (55) | (55) | (40) |
| Beaver Creek | 33.3 | 616 | 0—24.5 | 7.2—8.7 | 24—2,560 | | 6.2—13.8 | 232—6,200 | 458—2,270 |
| (near Trotters, ND—336600) | (0.01—2,350) | | (103) | (41) | (27) | | (20) | (98) | (18) |
| Hay Creek | | 4 | 0—15.5 | 7.5—8.3 | 22—2,580 | | | 170—1,950 | 105—671 |
| (No. 2 nr Wibaux, MT—336510) | (.09—66) | | (22) | (4) | (15) | | | (22) | (4) |
| Hay Creek | | 11 | 0—25 | 6.3—8.4 | 3—596 | | | 180—3,610 | 312—2,910 |
| (near Wibaux, MT—336515) | (0—76) | | (82) | (14) | (58) | | | (83) | (14) |
| Little Beaver Creek | | 96 | 0—24 | 7.48—8.4 | 12—500 | | | 300—6,000 | 595—3,550 |
| (near Wibaux. MT—336545) | (0—1,080) | | (63) | (10) | (15) | | | (64) | (10) |
| Little Beaver Creek | | 615 | 0—28 | 8.0—8.8 | | | | 216—2,600 | 347—1,880 |
| (nr. Marmarth, ND—335000) | (0.02—5,290) | | (113) | (25) | | | | (109) | (25) |
| Duck Creek | | 47 | 0—22 | 7.1—8.2 | 8—254 | | | 175—5,400 | 107—1,620 |
| (near Wibaux, MT—336447) | (0—416) | | (37) | (7) | (14) | | | (37) | (5) |
| Cotton Wood Creek | | | 7—12 | 7.4—8.2 | | | | 580—1,260 | |
| (NW of Alzada, MT) | (0.02—6) | | (4) | (5) | | | | (4) | |
| Little Missouri River | | | 0—27 | 7.2—8.2 | | 10—340[f] | | 529—2,367 | 1,126—1,636 |
| (near Capitol, MT) | (0—75) | | (7) | (4) | | (5) | | (6) | (3) |
| Little Missouri River | 120 | 1,970 | 0—31 | 7.5—8.3 | | | | 310—6,500 | 683—1,720 |
| (at Camp Crook, SD—334500) | (0.1—7,550) | | (187) | (11) | | | | (163) | (11) |
| Little Missouri River | | 4,570 | 0—31 | 6.9—9.2 | 20—21,600 | | | 250—3,960 | 220—2,410 |
| (at Marmarth, ND—335500) | (.1—24,000) | | (238) | (69) | (60) | | | (239) | (38) |
| Little Missouri River | | 6,190 | 0—30.5 | 6.9—8.5 | 191—29,100 | | | 307—4,200 | 486—1,970 |
| (at Medora ND—336000) | (1—22,800) | | (60) | (35) | (76) | | | (81) | (12) |

### Table E-4. Summary of Water Quality Data for Selected Stations in the Little Missouri Basin[a] (cont.)

| Station | Sulfate (mg/l) | Alkalinity (mg/l as CaCo$_3$) | Bicarbonate (mg/l) | Sodium Adsorption Ratio (SAR) | Dissolved Boron (_g/L) | Total Selenium (_g/L) | Total Arsenic (_g/L) | Nitrate—Nitrogen (mg/l) | Total Phosphorous (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| Beaver Creek<br>(at Wibaux, MT—336500) | 140—1,300<br>(56) | 120—510<br>(40) | | 2—7.3<br>(40) | 1—1,500<br>(56) | 0—1<br>(10) | 1—3<br>(10) | 0—1.6<br>(55) | 0.010—0.460<br>(55) |
| Beaver Creek<br>(near Trotters, ND—336600) | 49—1,200<br>(36) | 150—531<br>(15) | 188—647<br>(16) | 1.8—8.5<br>(20) | 60—100<br>(37) | 0—1<br>(2) | 2—5<br>(2) | 0—0.55<br>(15) | 0—0.43<br>(15) |
| Hay Creek<br>(No. 2 nr Wibaux, MT—336510) | 10—360<br>(4) | 75—170<br>(4) | 92—100<br>(2) | 0—0.7<br>(4) | 50—260<br>(4) | | | | |
| Hay Creek<br>(near Wibaux, MT—336515) | 140—1,800<br>(14) | 430—980<br>(10) | 120—530<br>(4) | 0.6—2.8<br>(14) | 1—880<br>(14) | | | | |
| Little Beaver Creek,<br>(near Wibaux. MT—336545) | 320—2,100<br>(10) | 130—620<br>(10) | 160—680<br>(3) | 2—9<br>(10) | 1—1,100<br>(10) | | | | |
| Little Beaver Creek<br>(nr. Marmarth, ND—335000) | 160—1,000<br>(25) | 65—594<br>(25) | 79—724<br>(25) | 2.5—12.0<br>(25) | 20—1,700<br>(25) | | | | |
| Duck Creek<br>(near Wibaux, MT—336447) | 25—980<br>(7) | 57—240<br>(7) | 70—160<br>(5) | 0.3—3.7<br>(4) | 80—920<br>(7) | | 1—10<br>(2) | 0.12—1.2<br>(2) | |
| Cotton Wood Cr.<br>(NW of Alzada, MT) | 415—600<br>(4) | 5—79<br>(5) | 6—96<br>(4) | | | | | 0.01—1.0<br>(4) | 0.11—0.44<br>(3) |
| Little Missouri River<br>(near Capitol, MT) | 620—864<br>(3) | 144—288<br>(5) | 176—351<br>(5) | | | 5<br>(1) | 1—10<br>(2) | 0.010—0.19<br>(6) | 0.020—0.424<br>(6) |
| Little Missouri River<br>(at Camp Crook, SD—334500) | 400—960<br>(11) | 62—349<br>(11) | 75—425<br>(11) | 2.1—6.0<br>(11) | 140—280<br>(11) | | | | |
| Little Missouri River<br>(at Marmarth, ND—335500) | (37) | 71—714<br>(37) | 64—799<br>(43) | 1.5—24.0<br>(39) | 0.08—950<br>(59) | 0—10[f]<br>(23) | 0—12[g]<br>(23) | | |
| Little Missouri River<br>(at Medora ND—336000) | 57—1,100<br>(35) | 104—400<br>(10) | 106—530<br>(35) | 4.5—11<br>(10) | 20—530<br>(14) | | | | |

ENDNOTES

[a]. Water Quality Data from U.S. EPA STORET Database; top values are range in observed data—value in ( ) is sample size.
[b]. Data collected by U.S. Geological Survey or Montana Department of Health and Environmental Sciences.
[c]. Discharge values in ( ) represent the range of flows for water quality observations. Where available, mean annual flow is given.
[d]. Value is NTU, Nepholometric Turbidity Units.
[e]. Value in microsiemens/centimeter.
[f]. Value is JTU, Jackson Turbidity Units.
[g]. Value is dissolved.

Table E-5

IMPAIRED OR THREATENED LAKES AND STREAMS IN THE LOWER MISSOURI BASIN: SUMMARY DATE: 11/18/92

| WATERBODY NAME<br>WATERBODY ID # / SEGMENT # | SIZE: (A)CERS(M)ILES | PROBABLE IMPAIRED USES (DEGREE OF USE SUPPORT) | PROBABLE CAUSES OF IMPAIRMENT (MAGNITUDE) | PROBABLE SOURCES OF IMPAIRMENT (MAGNITUDE) |
|---|---|---|---|---|
| MEDICINE LAKE<br>MT40R003 / 1 | 8599.00 A | 20(P) 24(P) 41(P) 42(P)<br>50(P) 72(F) 75(F) ( ) | 09(M) 13(M) 21(M) ( )<br>( ) ( ) ( ) ( ) | 10(M) 86(M) ( ) ( )<br>( ) ( ) ( ) ( ) |
| BIG MUDDY CREEK<br>MT40R001 / 1 | 54.80 M | 20(P) 24(P) 41(P) 42(P)<br>50(P) 72(F) 75(F) ( ) | 06(S) 09(M) 11(M) 12(M)<br>15(S) 21(M) ( ) ( ) | 02(M) 11(S) 12(M) 15(S)<br>86(M) ( ) ( ) ( ) |
| BIG MUDDY CREEK<br>MT40R001 / 2 | 50.20 M | 20(P) 24(P) 41(F) 42(F)<br>50(F) 72(F) 75(F) ( ) | 11(M) 15(S) 16(S) 21(M)<br>( ) ( ) ( ) ( ) | 11(S) 12(M) 15(S) 86(M)<br>( ) ( ) ( ) ( ) |
| BUTTE CREEK<br>MT40Q002 / 1 | 27.20 M | 20(F) 22(F) 41(F) 42(F)<br>50(P) 72(P) 75(F) ( ) | 13(M) ( ) ( ) ( )<br>( ) ( ) ( ) ( ) | 10(M) ( ) ( ) ( )<br>( ) ( ) ( ) ( ) |
| CHARLIE CREEK<br>MT40S004 / 1 | 16.20 M | 20(P) 24(P) 41(F) 42(F)<br>50(F) 72(F) 75(F) ( ) | 11(M) 13(M) 16(M) ( )<br>( ) ( ) ( ) ( ) | 10(M) ( ) ( ) ( )<br>( ) ( ) ( ) ( ) |
| EAST FORK POPLAR RIVER<br>MT40Q003 / 1 | 20.90 M | 20(P) 22(P) 41(P) 42(P)<br>50(P) 72(P) 75(F) ( ) | 05(M) 06(S) 08(S) 09(S)<br>12(M) 13(S) 15(M) ( ) | 11(S) 15(S) 74(M) 86(M)<br>( ) ( ) ( ) ( ) |
| EAST REDWATER CREEK<br>MT40P001 / 2 | 29.40 M | 20(P) 24(P) 41(F) 42(F)<br>50(P) 72(F) 75(F) ( ) | 11(M) 13(M) 16(M) ( )<br>( ) ( ) ( ) ( ) | 10(M) ( ) ( ) ( )<br>( ) ( ) ( ) ( ) |
| HARDSCRABBLE CREEK<br>MT40S004 / 2 | 18.80 M | 20(P) 24(P) 41(F) 42(F)<br>50(P) 72(F) 75(F) ( ) | 11(M) 13(M) 16(M) ( )<br>( ) ( ) ( ) ( ) | 10(M) ( ) ( ) ( )<br>( ) ( ) ( ) ( ) |
| MISSOURI RIVER<br>MT40S003 / 1 | 99.00 M | 20(P) 24(P) 41(P) 42(P)<br>50(P) 72(F) 75(F) ( ) | 05(M) 09(S) 16(M) 21(M)<br>( ) ( ) ( ) ( ) | 02(S) 11(S) 12(S) 74(M)<br>77(S) 86(M) ( ) ( ) |
| MISSOURI RIVER<br>MT40S001 / 1 | 89.20 M | 20(P) 24(P) 41(P) 42(P)<br>50(P) 72(F) 75(F) ( ) | 05(M) 09(S) 16(M) 21(M)<br>( ) ( ) ( ) ( ) | 02(S) 11(S) 12(S) 74(M)<br>77(S) 86(M) ( ) ( ) |
| POPLAR RIVER<br>MT40Q001 / 1 | 103.40 M | 20(P) 22(P) 41(P) 42(P)<br>50(P) 72(P) 75(F) ( ) | 08(S) 09(S) 10(S) 11(S)<br>13(S) 14(S) ( ) ( ) | 11(S) 12(S) 15(S) 86(S)<br>( ) ( ) ( ) ( ) |
| PRAIRIE ELK CREEK<br>MT40S002 / 1 | 25.90 M | 20(P) 24(P) 41(F) 42(F)<br>50(F) 72(F) 75(F) ( ) | 05(M) 09(S) 21(M) ( )<br>( ) ( ) ( ) ( ) | 15(S) 86(M) ( ) ( )<br>( ) ( ) ( ) ( ) |
| REDWATER RIVER<br>MT40P001 / 1 | 111.30 M | 20(P) 24(P) 41(F) 42(F)<br>50(F) 72(F) 75(F) ( ) | 11(S) 14(S) 21(S) ( )<br>( ) ( ) ( ) ( ) | 11(S) 15(S) 86(S) ( )<br>( ) ( ) ( ) ( ) |

IMPAIRED OR THREATENED LAKES AND STREAMS IN THE LOWER MISSOURI BASIN: SUMMARY DATE: 11/18/92

| WATERBODY NAME<br>WATERBODY ID # / SEGMENT # | SIZE: (A)CERS(M)ILES | PROBABLE IMPAIRED USES (DEGREE OF USE SUPPORT) | PROBABLE CAUSES OF IMPAIRMENT (MAGNITUDE) | PROBABLE SOURCES OF IMPAIRMENT (MAGNITUDE) |
|---|---|---|---|---|
| SAND CREEK | 13.20 M | 20(P) 24(P) 41(F) 42(F) | 05(M) 09(S) 21(M) ( ) | 86(M) ( ) ( ) ( ) |
| MT40S002 / 2 | | 50(F) 72(F) 75(F) ( ) | ( ) ( ) ( ) ( ) | ( ) ( ) ( ) ( ) |

IMPAIRED OR THREATENED LAKES AND STREAMS IN THE MILK BASIN: SUMMARY DATE: 11/18/92

| WATERBODY NAME<br>WATERBODY ID # / SEGMENT # | SIZE: (A)CERS(M)ILES | PROBABLE IMPAIRED USES (DEGREE OF USE SUPPORT) | PROBABLE CAUSES OF IMPAIRMENT (MAGNITUDE) | PROBABLE SOURCES OF IMPAIRMENT (MAGNITUDE) |
|---|---|---|---|---|
| EAGLE NEST COULEE<br>MT40N001 / 1 | 9.00 M | 20(F) 24(T) 41(F) 42(F)<br>50(F) 72(F) 75(F) ( ) | 14(T) 15(T) 21(T) ( )<br>( ) ( ) ( ) ( ) | 15(T) 86(T) ( ) ( )<br>( ) ( ) ( ) ( ) |
| FRENCHMAN CREEK<br>MT40L001 / 1 | 52.30 M | 20(F) 24(F) 41(F) 42(F)<br>50(T) 72(F) 75(F) ( ) | 08(T) ( ) ( ) ( )<br>( ) ( ) ( ) ( ) | 86(T) ( ) ( ) ( )<br>( ) ( ) ( ) ( ) |
| LITTLE BOXELDER CREEK<br>MT40J002 / 3 | 30.20 M | 20(P) 22(P) 41(F) 42(F)<br>50(F) 72(F) 75(F) ( ) | 09(M) 11(M) 14(M) ( )<br>( ) ( ) ( ) ( ) | 12(M) 15(M) 77(M) ( )<br>( ) ( ) ( ) ( ) |
| LITTLE PEOPLES CREEK<br>MT40I001 / 1 | 19.50 M | 20(P) 22(P) 41(F) 42(F)<br>50(P) 72(F) 75(F) ( ) | 05(M) 21(S) ( ) ( )<br>( ) ( ) ( ) ( ) | 15(S) 51(M) ( ) ( )<br>( ) ( ) ( ) ( ) |
| LODGE CREEK<br>MT40J003 / 1 | 51.70 M | 20(F) 24(T) 41(T) 42(F)<br>50(T) 72(T) 75(F) ( ) | 08(T) 09(T) 12(T) 13(T)<br>22(T) ( ) ( ) ( ) | 12(T) 15(T) ( ) ( )<br>( ) ( ) ( ) ( ) |
| MILK RIVER<br>MT40F001 / 1 | 37.20 M | 20(P) 22(P) 41(F) 42(F)<br>50(F) 72(F) 75(F) ( ) | 09(S) 11(M) 13(S) ( )<br>( ) ( ) ( ) ( ) | 11(M) 12(M) 14(M) ( )<br>( ) ( ) ( ) ( ) |
| MILK RIVER<br>MT40O001 / 1 | 67.70 M | 20(P) 24(P) 41(F) 42(F)<br>50(P) 72(P) 75(F) ( ) | 08(S) 09(S) 13(M) 15(M)<br>16(M) 21(M) ( ) ( ) | 02(S) 11(M) 12(M) 15(M)<br>77(M) ( ) ( ) ( ) |
| MILK RIVER<br>MT40J001 / 1 | 176.90 M | 20(P) 24(P) 41(F) 42(F)<br>50(P) 72(P) 75(F) ( ) | 08(S) 09(S) 13(M) 15(M)<br>16(M) 21(M) ( ) ( ) | 02(S) 11(M) 12(M) 15(M)<br>77(M) ( ) ( ) ( ) |
| MILK RIVER<br>MT40O001 / 2 | 46.90 M | 20(P) 24(P) 41(F) 42(F)<br>50(P) 72(P) 75(F) ( ) | 08(S) 09(S) 13(M) 15(M)<br>16(M) 21(M) ( ) ( ) | 02(M) 11(M) 12(M) 15(M)<br>77(M) ( ) ( ) ( ) |
| MILK RIVER<br>MT40F003 / 1 | 21.70 M | 20(P) 24(P) 41(F) 42(F)<br>50(F) 72(F) 75(F) ( ) | 09(S) 11(M) 13(S) 15(M)<br>16(M) ( ) ( ) ( ) | 11(M) 12(M) 14(M) ( )<br>( ) ( ) ( ) ( ) |
| PEOPLES CREEK<br>MT40I001 / 2 | 34.70 M | 20(P) 22(P) 24(P) 41(F)<br>42(F) 50(P) 72(P) 75(F) | 08(M) 13(M) 14(S) 15(S)<br>21(M) ( ) ( ) ( ) | 12(M) 15(M) ( ) ( )<br>( ) ( ) ( ) ( ) |
| SAGE CREEK<br>MT40G001 / 1 | 57.20 M | 20(N) 22(N) 41(F) 42(F)<br>50(N) 72(P) 75(F) ( ) | 13(H) 14(H) ( ) ( )<br>( ) ( ) ( ) ( ) | 11(H) 12(H) ( ) ( )<br>( ) ( ) ( ) ( ) |
| WHITEWATER CREEK<br>MT40K001 / 1 | 53.10 M | 20(P) 24(P) 41(F) 42(F)<br>50(F) 72(F) 75(F) ( ) | 11(M) 15(M) ( ) ( )<br>( ) ( ) ( ) ( ) | 12(M) 15(M) 86(M) ( )<br>( ) ( ) ( ) ( ) |

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IMPAIRED OR THREATENED LAKES AND STREAMS IN THE MILK BASIN:                                            SUMMARY DATE: 11/18/92
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                                                    PROBABLE IMPAIRED          PROBABLE CAUSES            PROBABLE SOURCES
     WATERBODY NAME                  SIZE:           USES (DEGREE OF            OF IMPAIRMENT              OF IMPAIRMENT
WATERBODY ID # / SEGMENT #        (A)CERS(M)ILES       USE SUPPORT)               (MAGNITUDE)                (MAGNITUDE)
-----------------------------------------------------------------------------------------------------------------------------

WILLOW CREEK                           37.80 M    20(P) 24(P) 41(F) 42(F)     11(M) 15(M) 16(M)   ( )     73(M) 86(M)   ( )   ( )
  MT400002  / 3                                   50(F) 72(F) 75(F)   ( )       ( )   ( )   ( )   ( )       ( )   ( )   ( )   ( )
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IMPAIRED OR THREATENED LAKES AND STREAMS IN THE LITTLE MISSOURI BASIN: SUMMARY DATE: 11/18/92

| WATERBODY NAME<br>WATERBODY ID # / SEGMENT # | SIZE:<br>(A)CERS(M)ILES | PROBABLE IMPAIRED USES (DEGREE OF USE SUPPORT) | PROBABLE CAUSES OF IMPAIRMENT (MAGNITUDE) | PROBABLE SOURCES OF IMPAIRMENT (MAGNITUDE) |
|---|---|---|---|---|
| BEAVER CREEK | 72.44 M | 20(P) 24(P) 41(P) 42(P) | 09(S) 11(M) ( ) ( ) | 11(S) 77(M) 86(M) ( ) |
| MT39G001 / 1 | | 50(F) 72(F) 75(F) ( ) | ( ) ( ) ( ) ( ) | ( ) ( ) ( ) ( ) |
| LITTLE MISSOURI RIVER | 74.39 M | 20(F) 24(T) 41(F) 42(F) | 14(T) 15(T) 21(T) ( ) | 15(T) 86(T) ( ) ( ) |
| MT39F001 / 2 | | 50(F) 72(F) 75(F) ( ) | ( ) ( ) ( ) ( ) | ( ) ( ) ( ) ( ) |
| THOMPSON CREEK | 25.40 M | 20(P) 24(P) 41(F) 42(F) | 11(M) 21(M) ( ) ( ) | 15(S) 86(M) ( ) ( ) |
| MT39F001 / 1 | | 50(F) 72(F) 75(F) ( ) | ( ) ( ) ( ) ( ) | ( ) ( ) ( ) ( ) |
| WILLOW CREEK | 14.60 M | 20(P) 24(P) 41(F) 42(F) | 11(M) 21(M) ( ) ( ) | 15(S) 86(M) ( ) ( ) |
| MT39F001 / 3 | | 50(F) 72(F) 75(F) ( ) | ( ) ( ) ( ) ( ) | ( ) ( ) ( ) ( ) |

Source: DHES 1992

MAGNITUDE:

H - HIGH
M - MODERATE
S - SLIGHT
T - THREATENED

LEVEL OF SUPPORT:

F - FULLY SUPPORTING
P - PARTIALLY SUPPORTING
N - NOT SUPPORTING
T - THREATENED

USES:

01 - OVERALL USE SUPPORT
20 - AQUATIC LIFE SUPPORT
21 - FISH CONSUMPTION
22 - COLD WATER FISHERY
23 - SHELLFISHING
24 - WARM WATER FISHERY
29 - RECREATION
32 - SECONDARY WARM WATER FISHERY
40 - CONTACT RECREATION
41 - RECREATION
42 - SWIMMING
44 - SECONDARY CONTACT REC
46 - NON-CONTACT RECREATION
50 - DRINKING WATER SUPPLY
52 - AQUIFER PROTECTION
60 - NONDEGRADATION
62 - AESTHETICS
70 - MULTIPURPOSE USE
72 - AGRICULTURE
73 - AGRICULTURE - IRRIGATION
74 - AGRICULTURE - LIVESTOCK
75 - INDUSTRIAL USE
78 - NAVIGATION
79 - HYDROELECTRIC POWER

CAUSES:

00 - Cause Unknown
01 - Unknown toxicity
02 - Pesticides
03 - Priority organics
04 - Nonpriority organics
05 - Metals
06 - Unionized Ammonia
07 - Chlorine
08 - Other inorganics
09 - Nutrients
10 - pH
11 - Siltation
12 - Organic enrichment/DO
13 - Salinity/TDS/chlorides
14 - Thermal modifications
15 - Flow alteration
16 - Other habitat alterations
17 - Pathogens
18 - Radiation
19 - Oil and grease
20 - Taste and odor
21 - Suspended solids
22 - Noxious aquatic plants
23 - Filling and draining
24 - Total toxics
25 - Turbidity
26 - Exotic species

SOURCES:

01 - Industrial Point Sources
02 - Municipal Point Sources
04 - Combined Sewer Overflow
10 - Agriculture
11 - Nonirrigated crop production
12 - Irrigated crop production
13 - Specialty crop production
14 - Pasture land
15 - Range land
16 - Feedlots - all types
17 - Aquaculture
18 - Animal holding/management areas
19 - Manure lagoons
20 - Silviculture
21 - Harvesting,restoration,residue mngmt.
22 - Forest management
23 - Road construction/maintenance
30 - Construction
31 - Highway/road/bridge
32 - Land development
40 - Urban runoff/Storm sewers
50 - Resource extraction
51 - Surface Mining
52 - Subsurface mining
53 - Placer mining
54 - Dredge mining
55 - Petroleum activities
56 - Mill tailings
57 - Mine tailings
60 - Land disposal
61 - Sludge
62 - Wastewater
63 - Landfills
64 - Industrial land treatment
65 - Onsite wastewater systems (septic tanks)
66 - Hazardous waste
67 - Septage disposal
70 - Hydromodification
71 - Channelization
72 - Dredging
73 - Dam construction
74 - Flow regulation/modification
75 - Bridge construction
76 - Removal of riparian vegetation
77 - Streambank modification/destabilization
78 - Drainage/filling of wetlands
80 - Other
81 - Atmospheric deposition
82 - Waste storage/storage tank leaks
83 - Highway maintenance and runoff
84 - Spills
85 - In-place contaminants
86 - Natural
87 - Recreational activities

# APPENDIX F

## LOWER MISSOURI VALLEY VEGETATION UNDER EXISTING CONDITIONS AND THE CONSUMPTIVE USE ALTERNATIVE AND PROJECTS AFFECTING WETLANDS IN SHERIDAN COUNTY

**KEY TO VEGETATION TYPES:**

- Woodland and Shrub/Scrub: land with a forest or shrub canopy cover greater than 15 percent
- Mixed Prairie: grasslands with scattered trees or small groves of trees
- Prairie: grasslands used for pasture and marsh
- Irrigated cropland: all irrigated land
- Nonirrigated cropland: includes grain fields and hay fields

# LOWER MISSOURI VALLEY VEGETATION

## LOCATION MAP

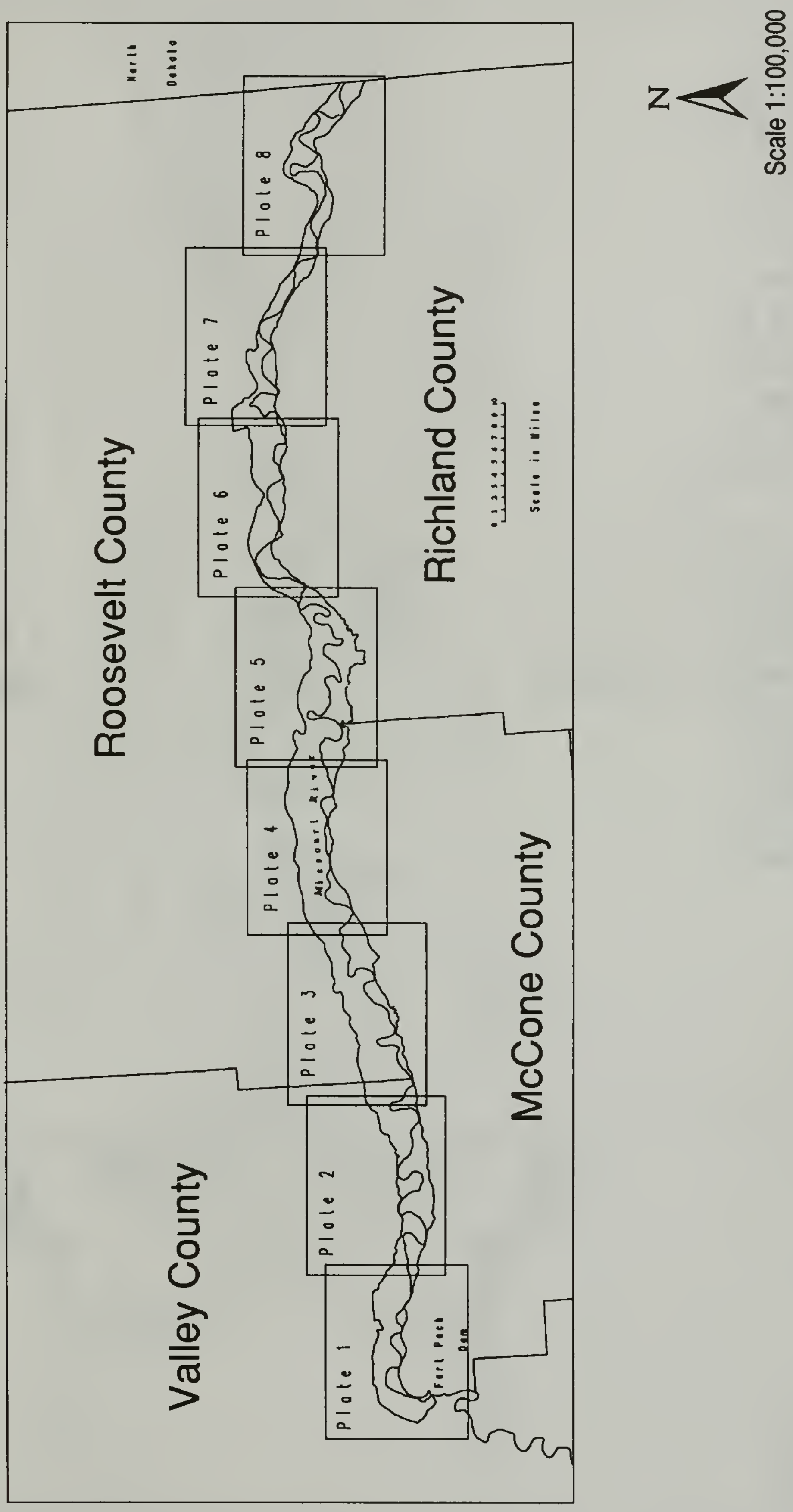


Plate 1

# EXISTING VEGETATION

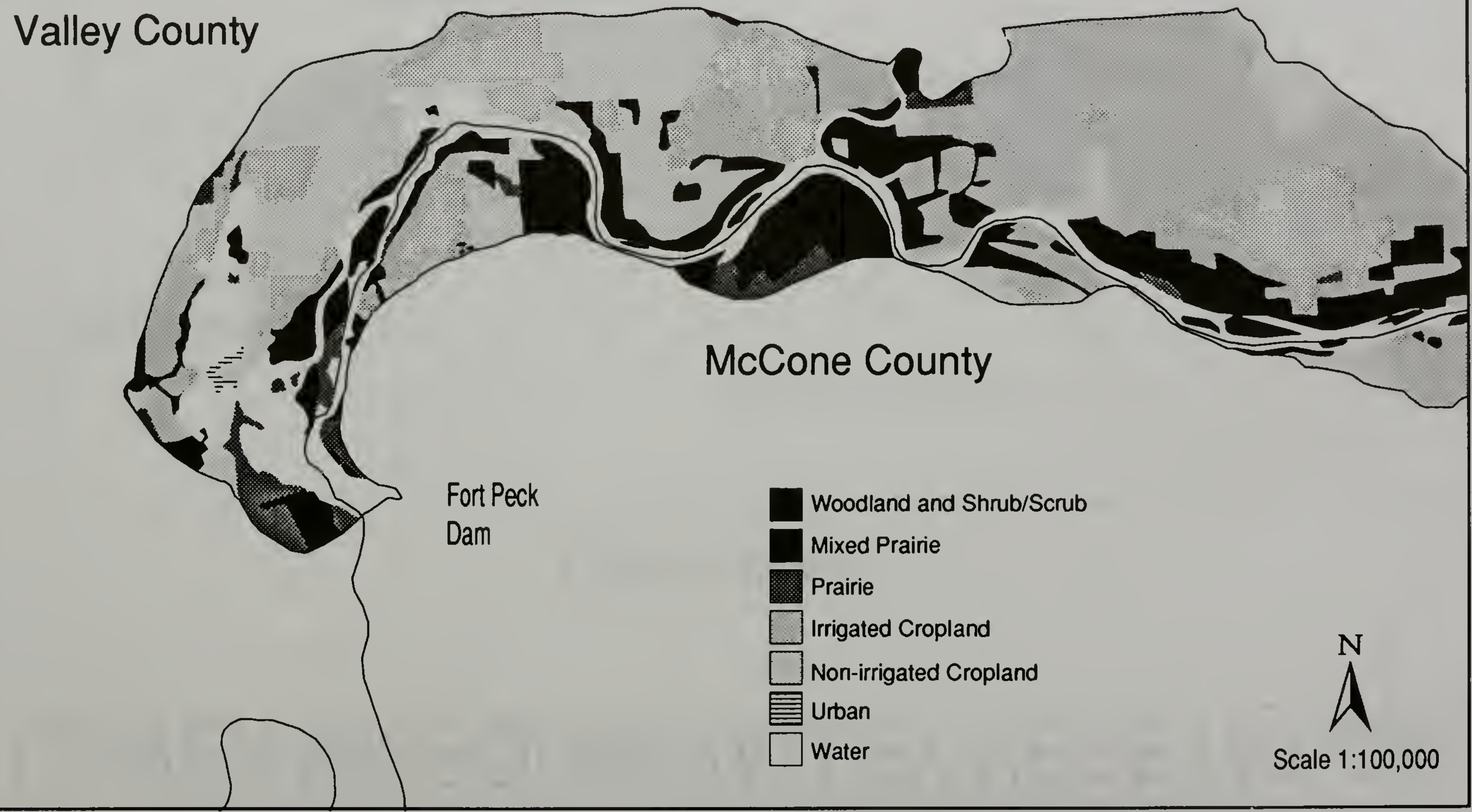


Plate 1

# CONSUMPTIVE USE ALTERNATIVE

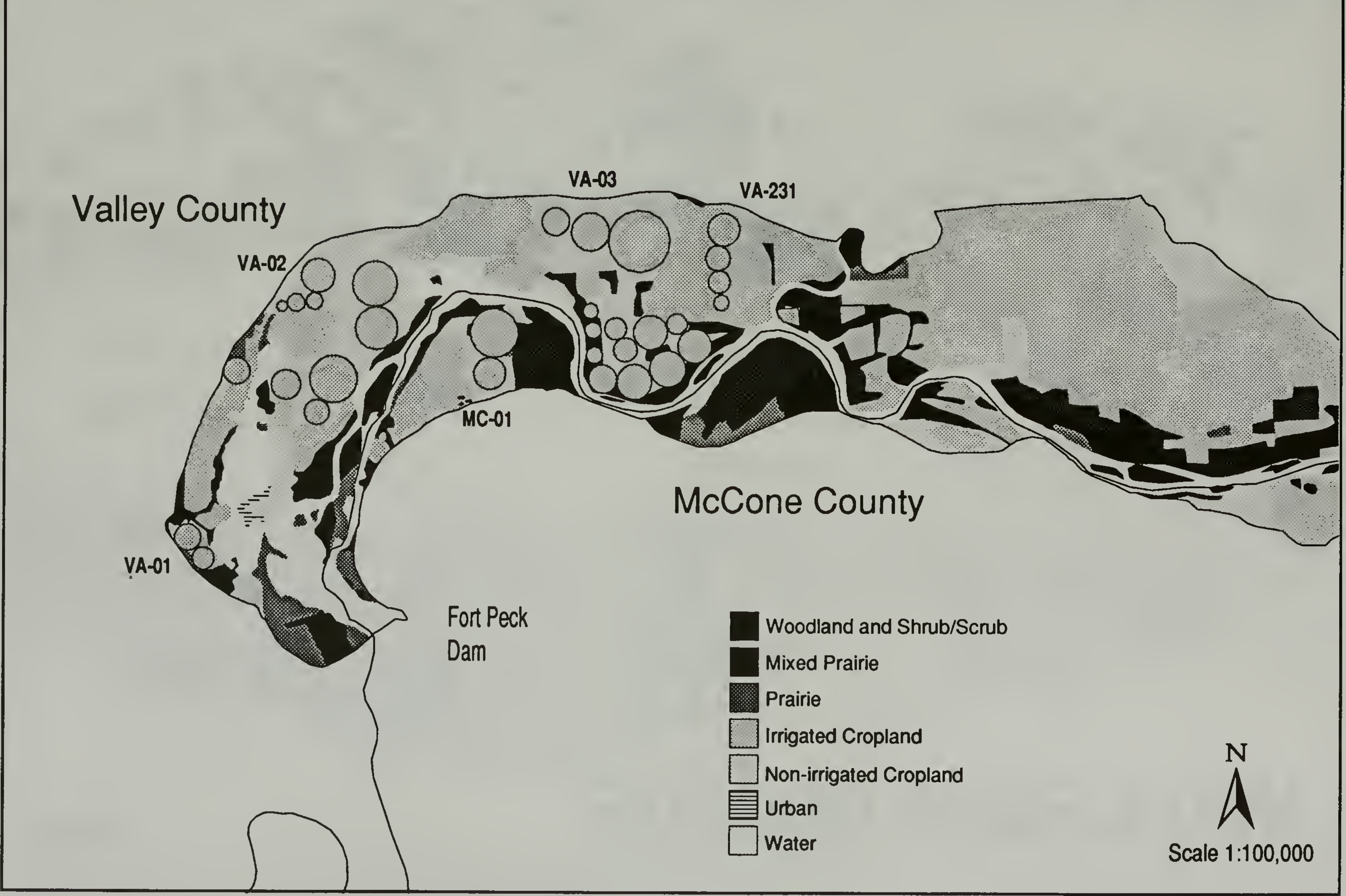


Plate 2

# EXISTING VEGETATION

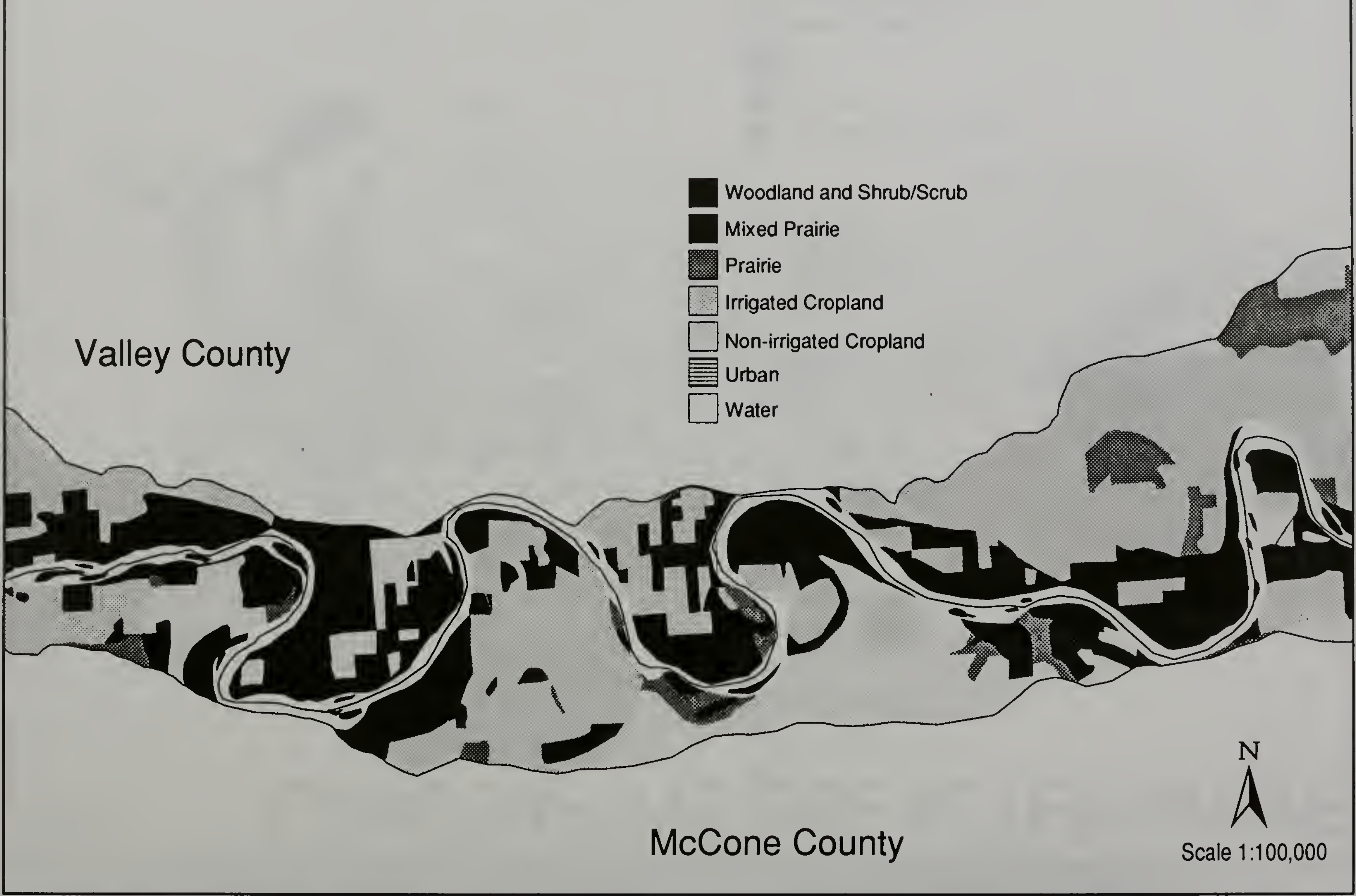
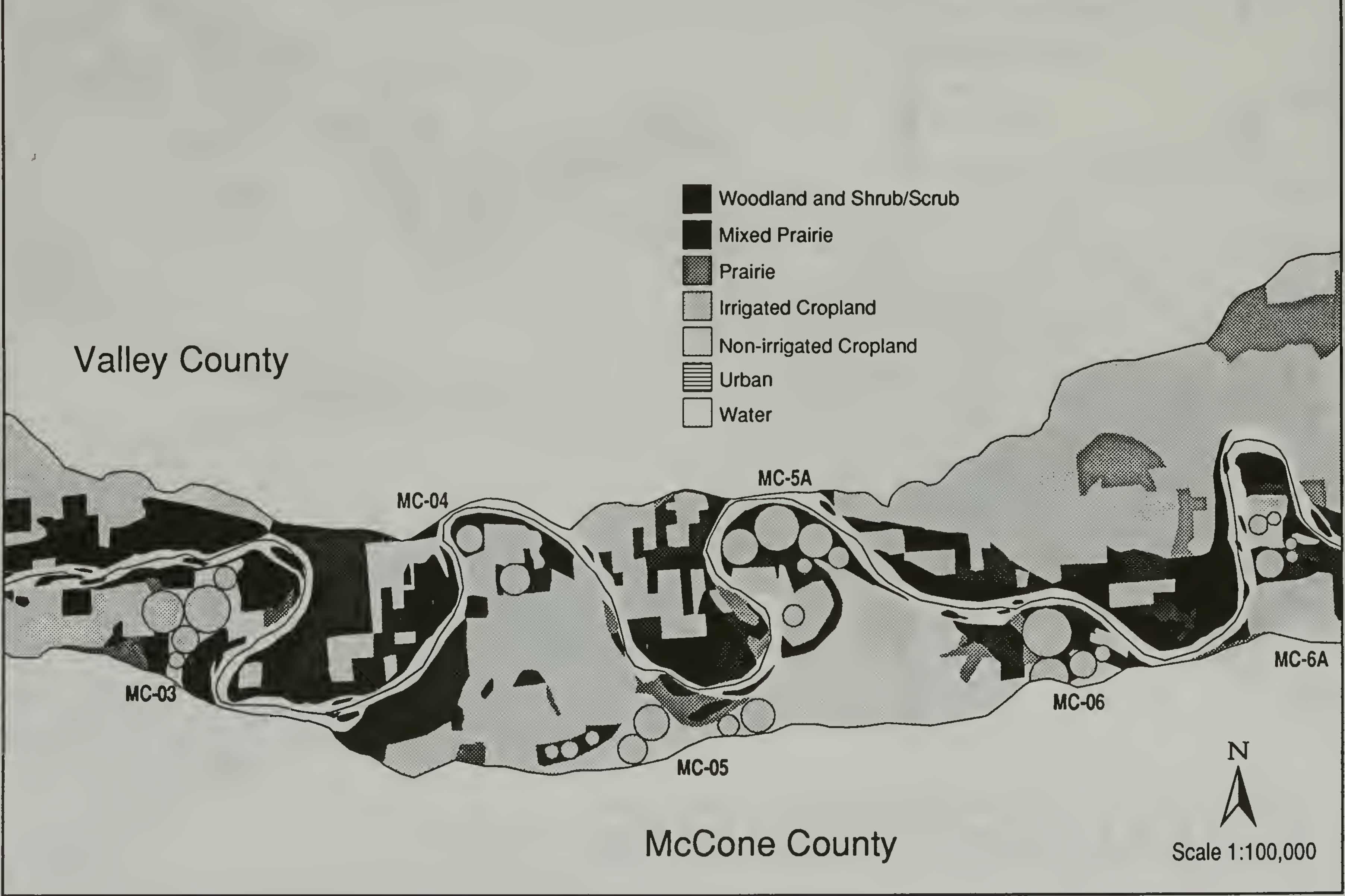


Plate 2

# CONSUMPTIVE USE ALTERNATIVE



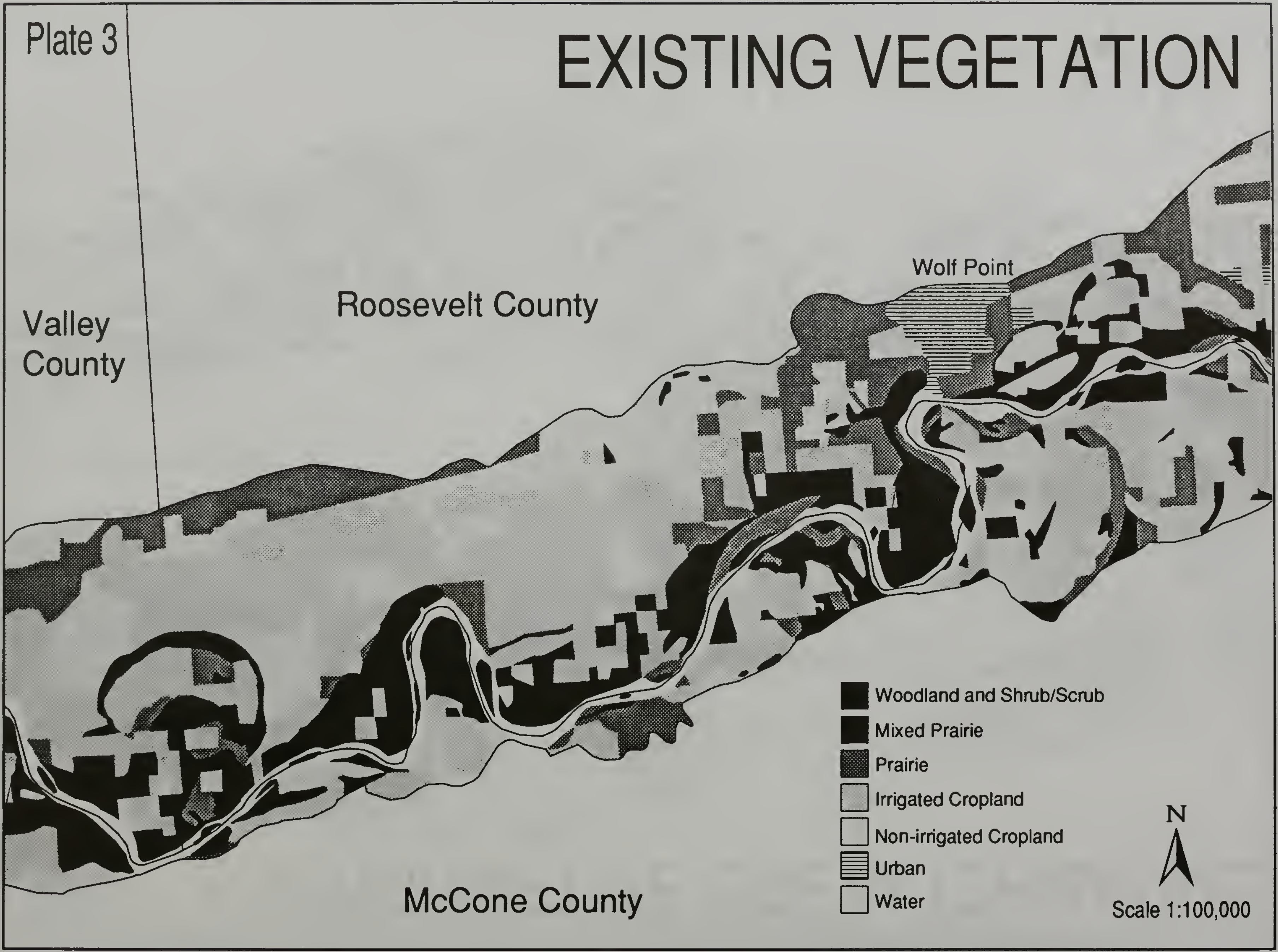


Plate 3

EXISTING VEGETATION

Plate 3

# CONSUMPTIVE USE ALTERNATIVE

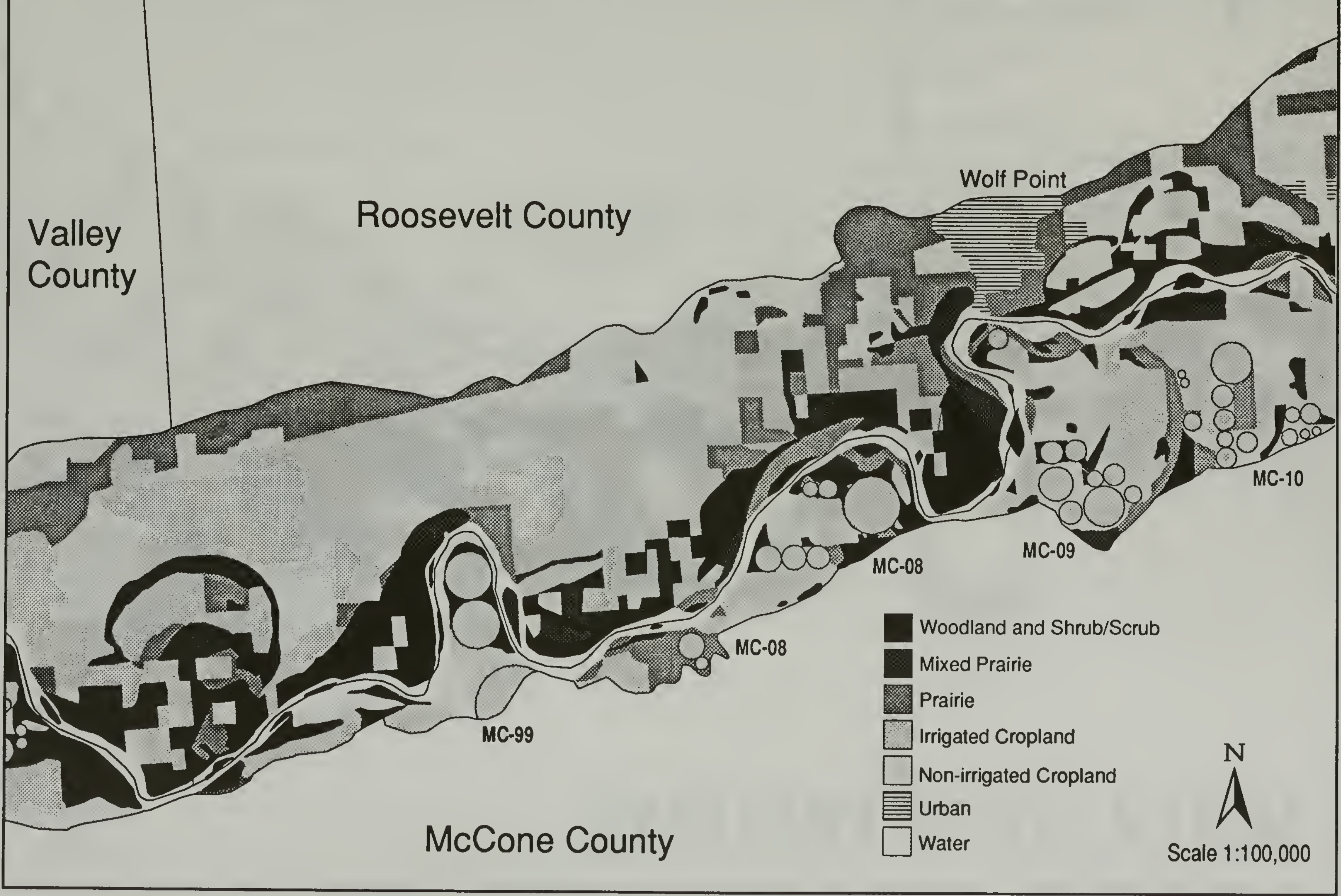


Plate 4

# EXISTING VEGETATION

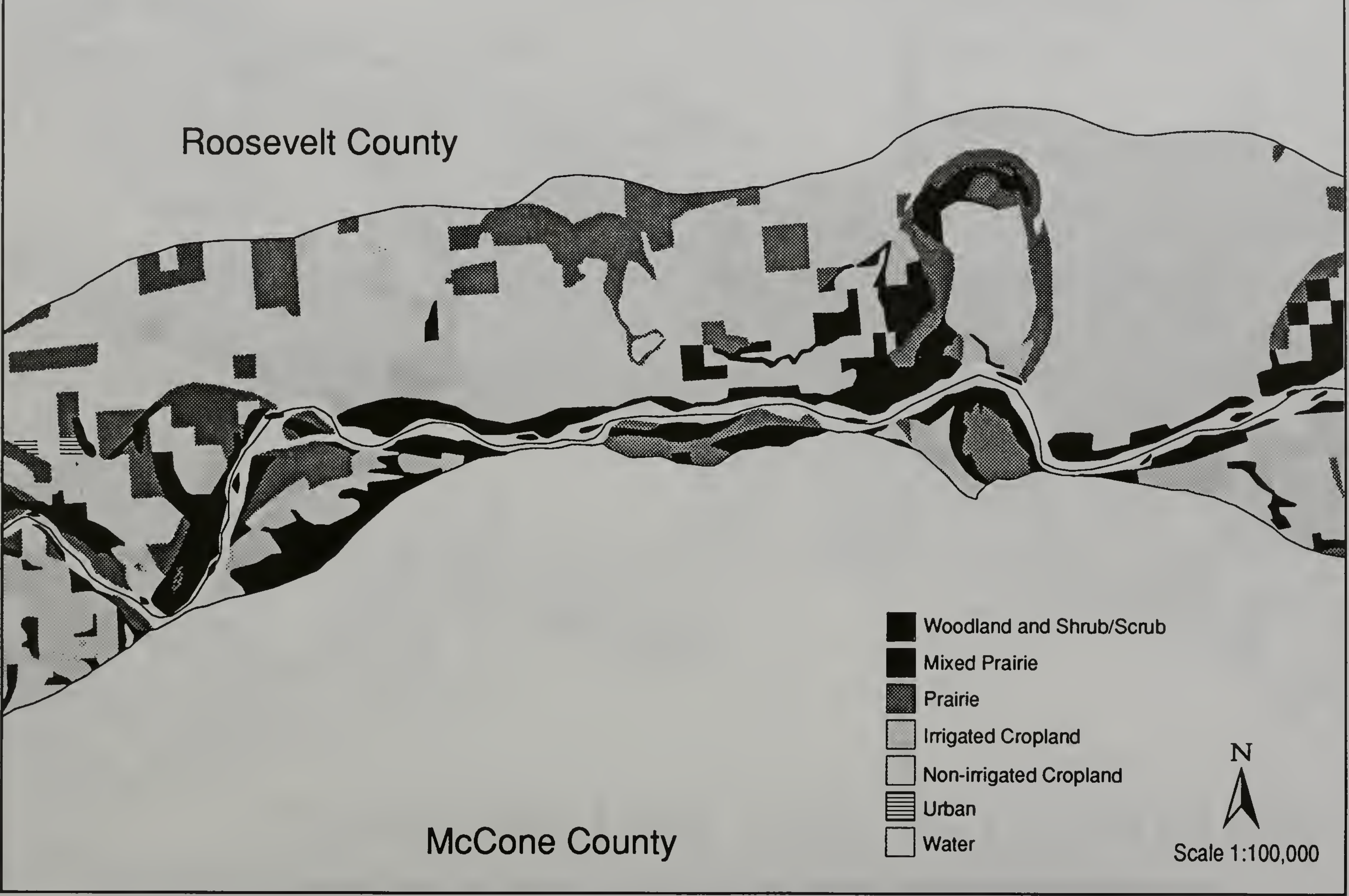
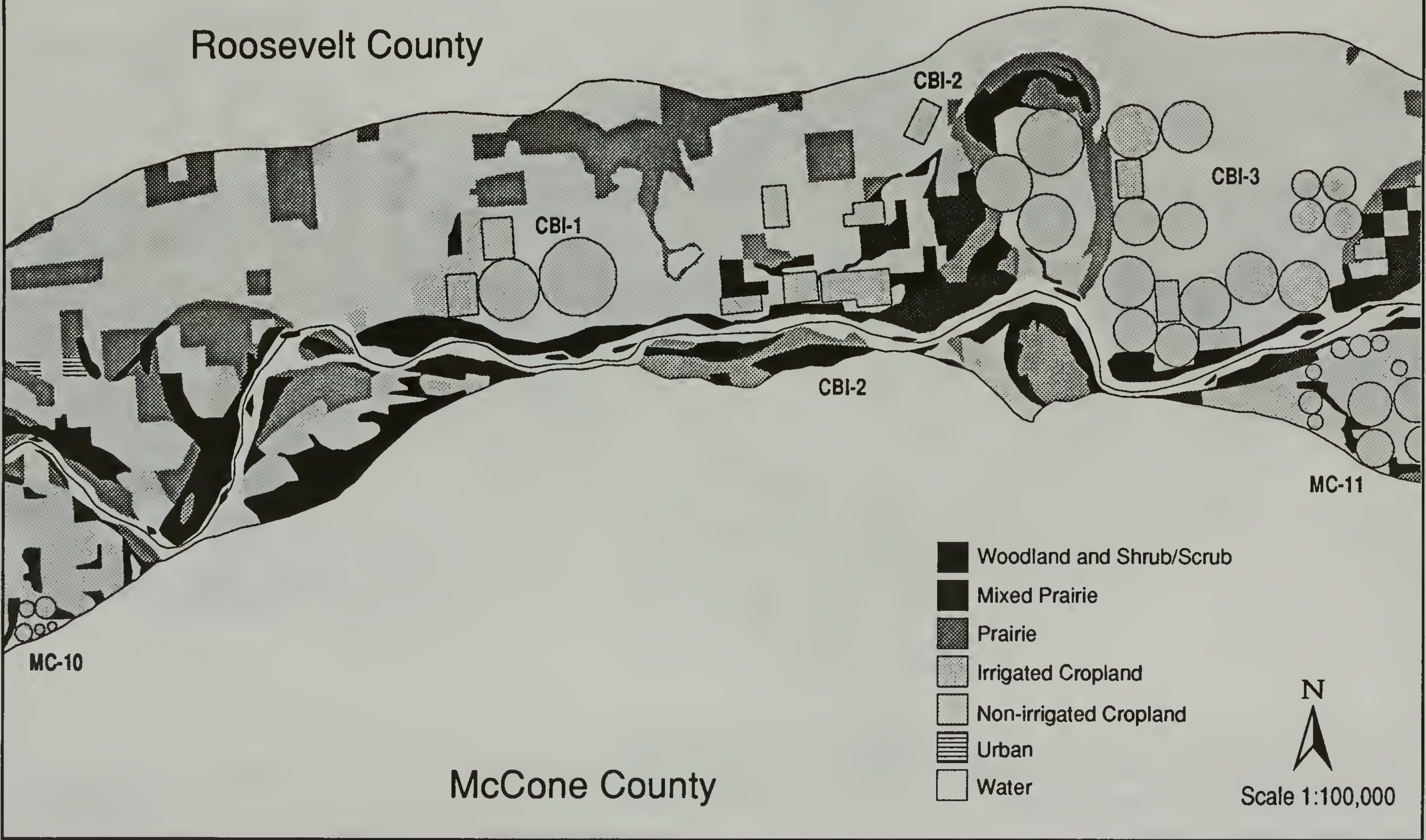


Plate 4

# CONSUMPTIVE USE ALTERNATIVE



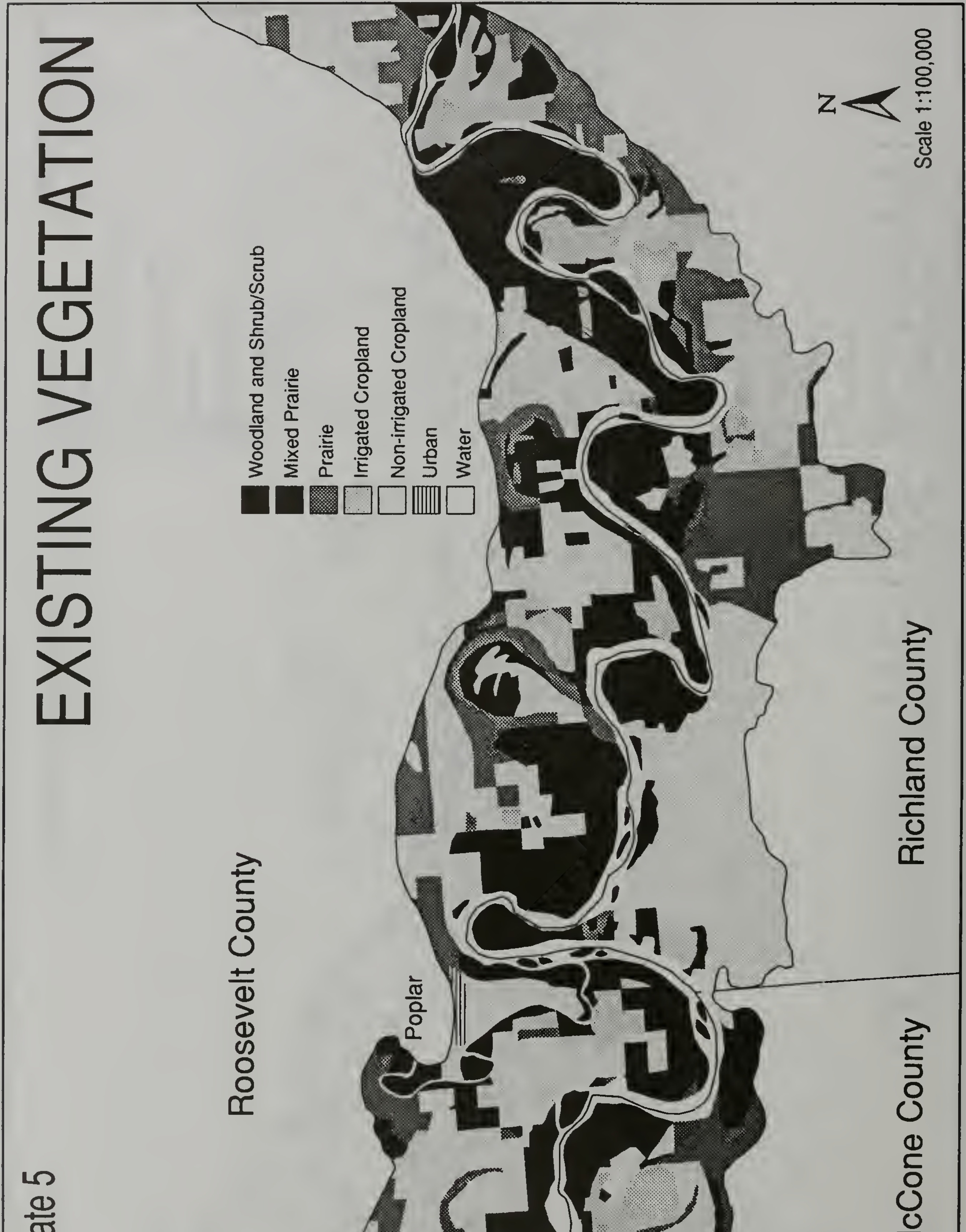
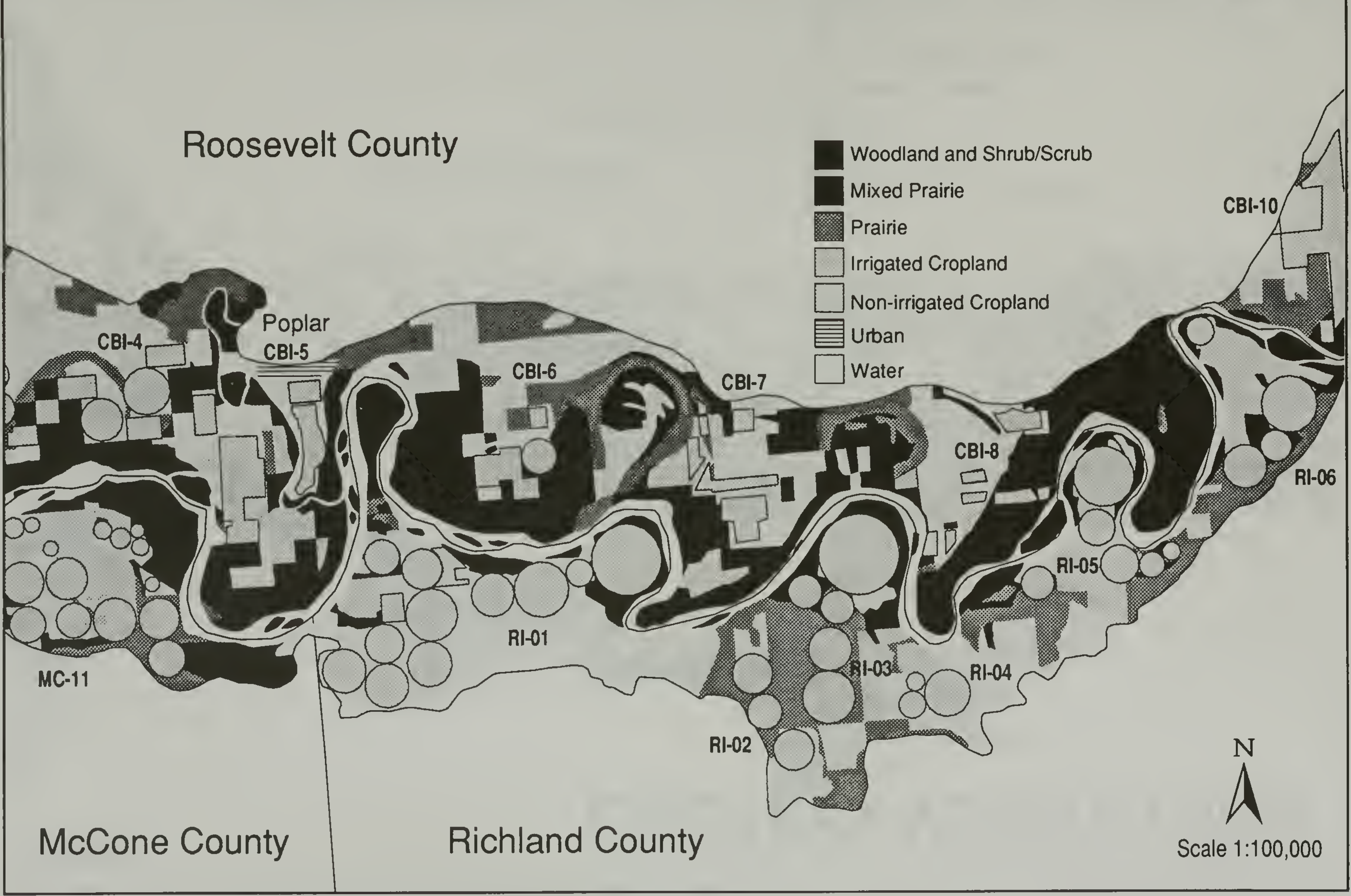


Plate 5

EXISTING VEGETATION

Plate 5

# CONSUMPTIVE USE ALTERNATIVE



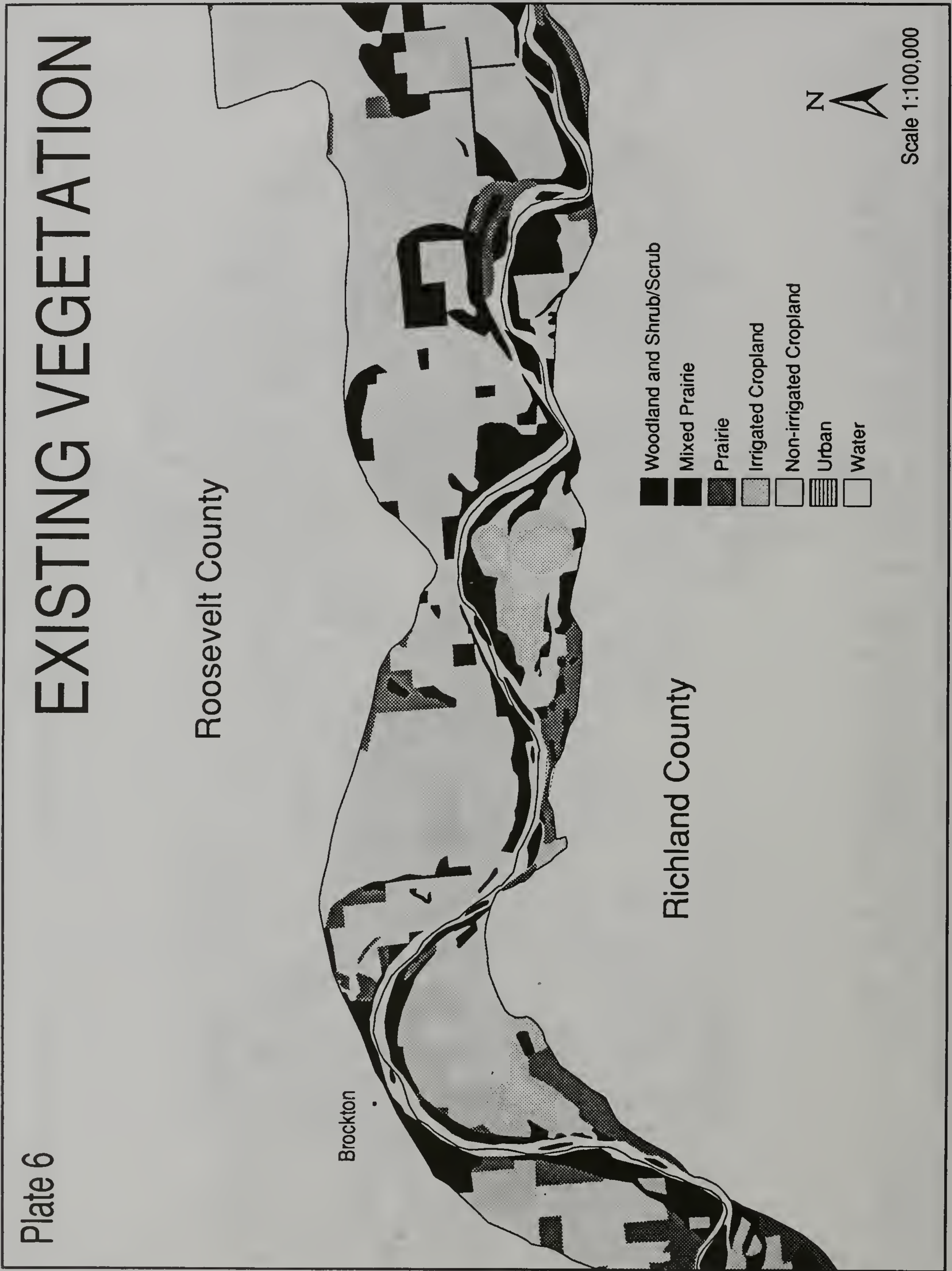


Plate 6
EXISTING VEGETATION
Roosevelt County
Richland County
Brockton
Woodland and Shrub/Scrub
Mixed Prairie
Prairie
Irrigated Cropland
Non-irrigated Cropland
Urban
Water
N
Scale 1:100,000

Plate 6

# CONSUMPTIVE USE ALTERNATIVE

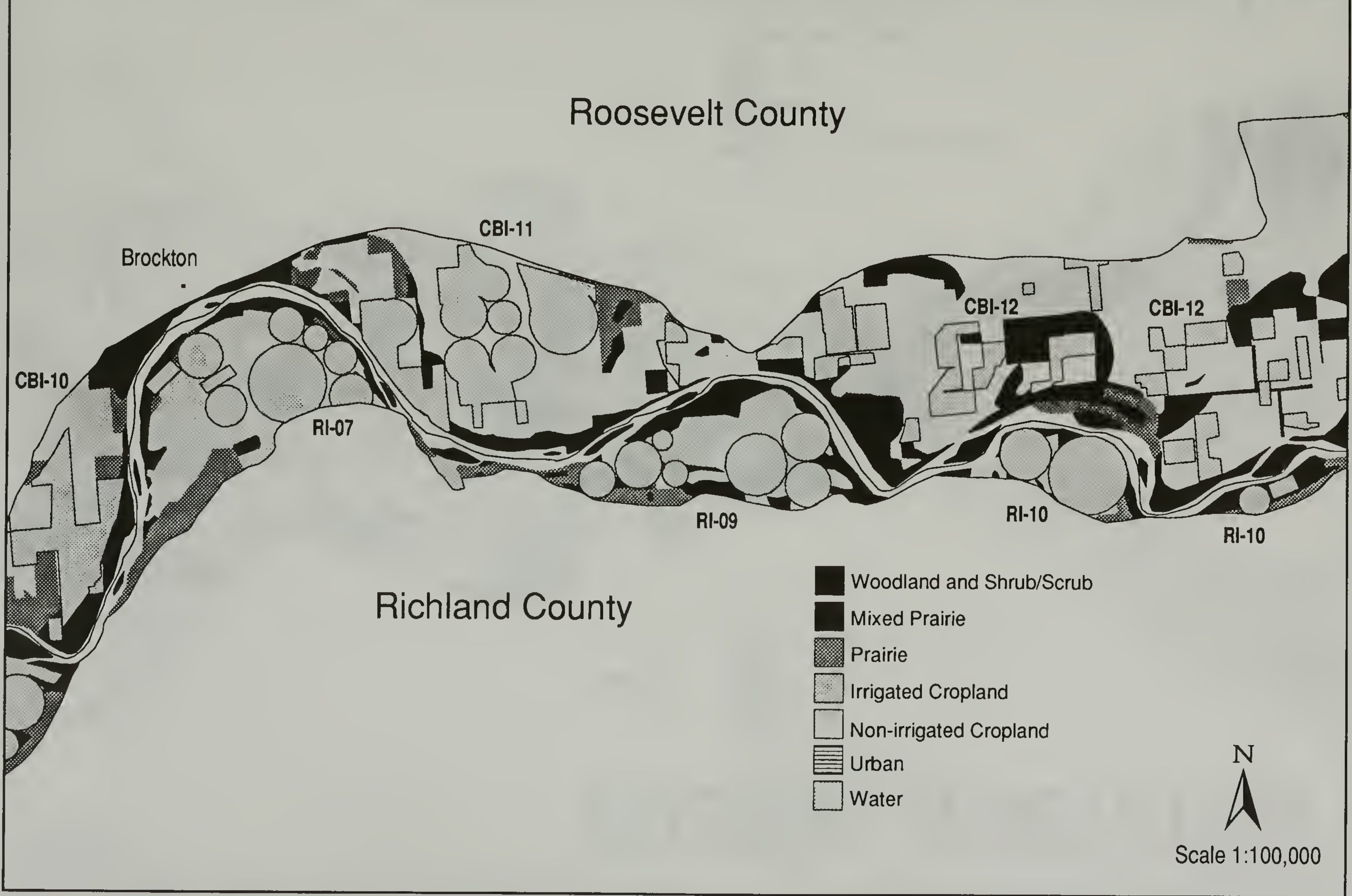
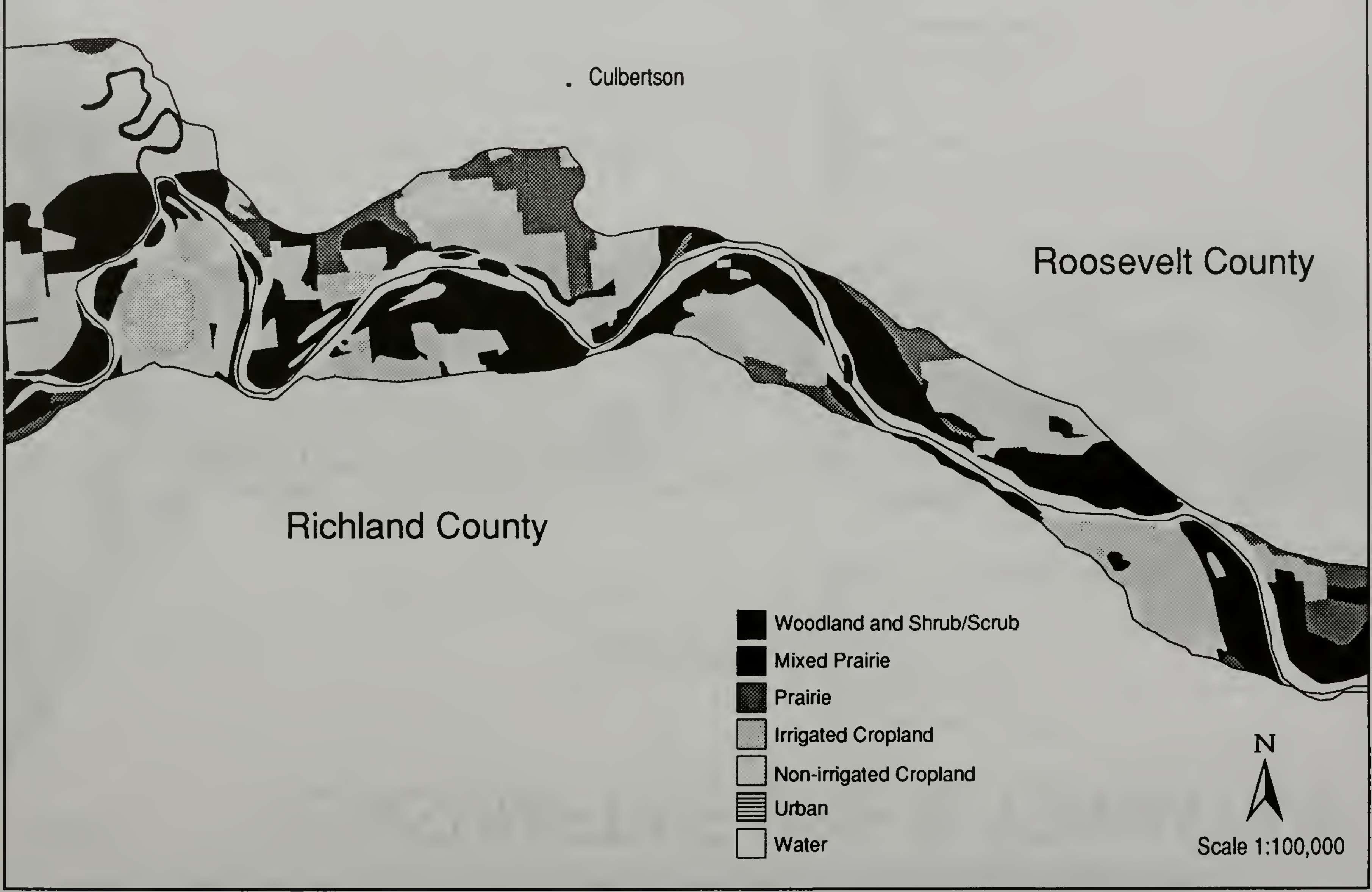


Plate 7

# EXISTING VEGETATION



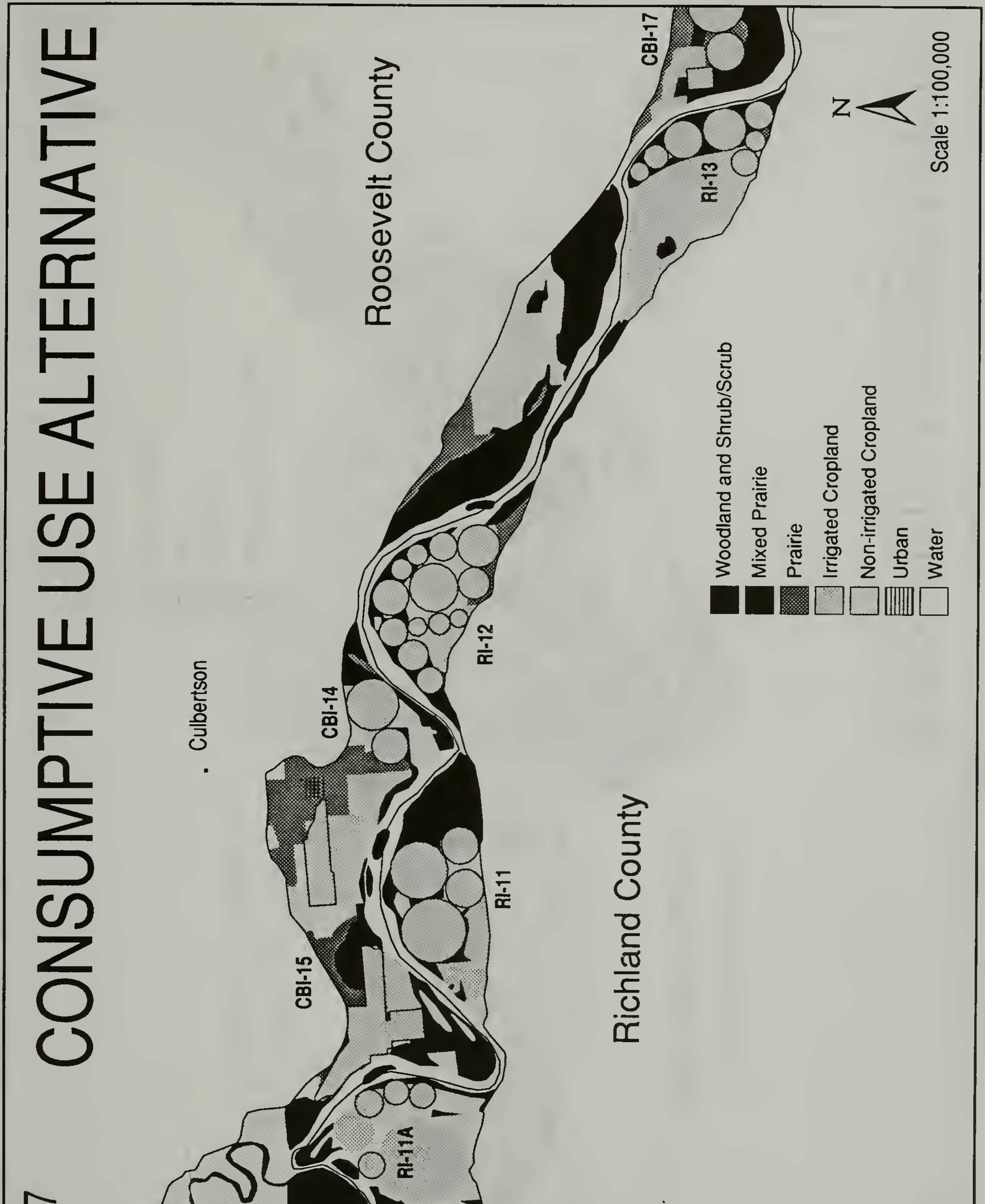


Plate 7

CONSUMPTIVE USE ALTERNATIVE

Plate 8

# EXISTING VEGETATION

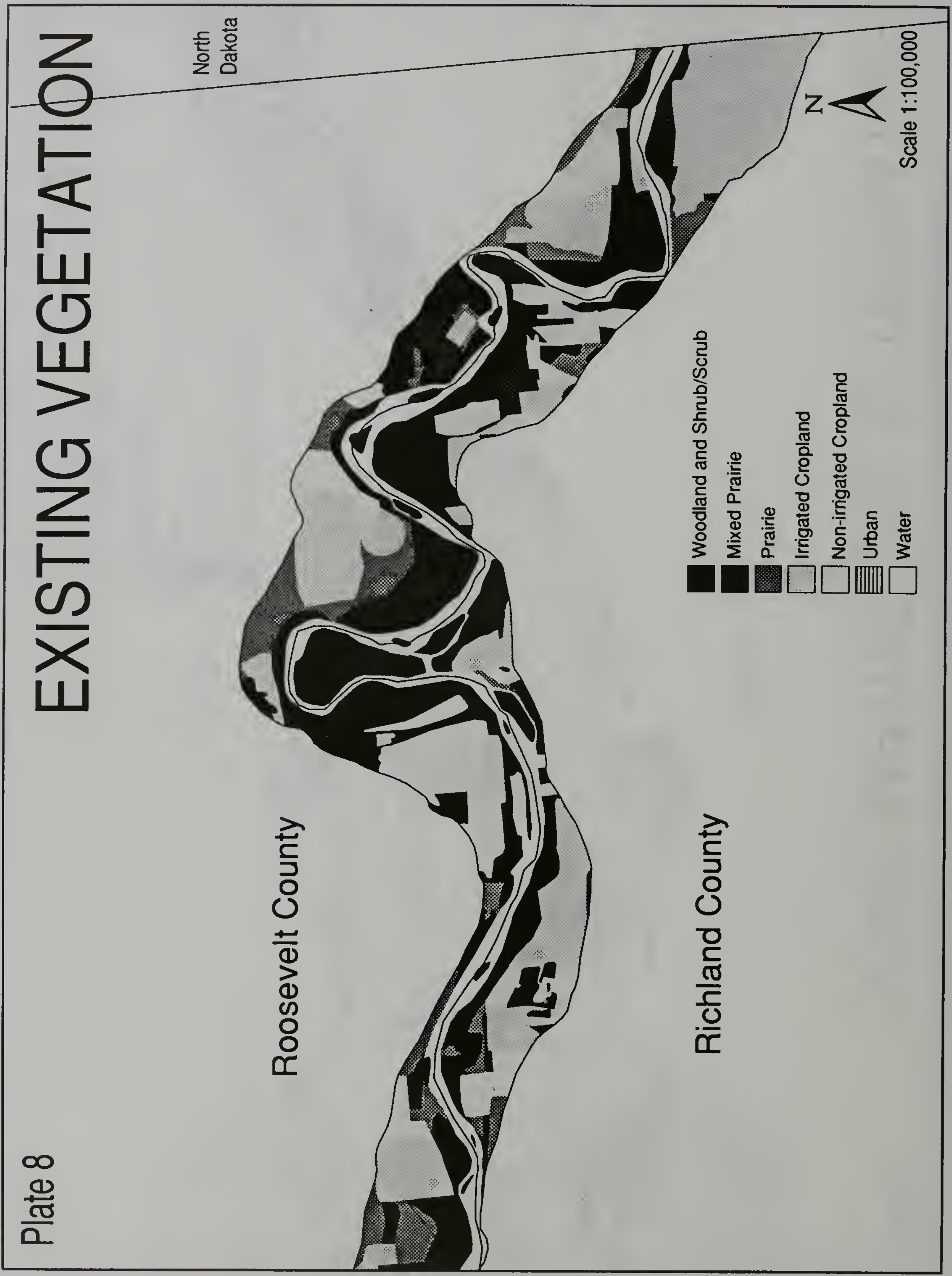


Plate 8

# CONSUMPTIVE USE ALTERNATIVE

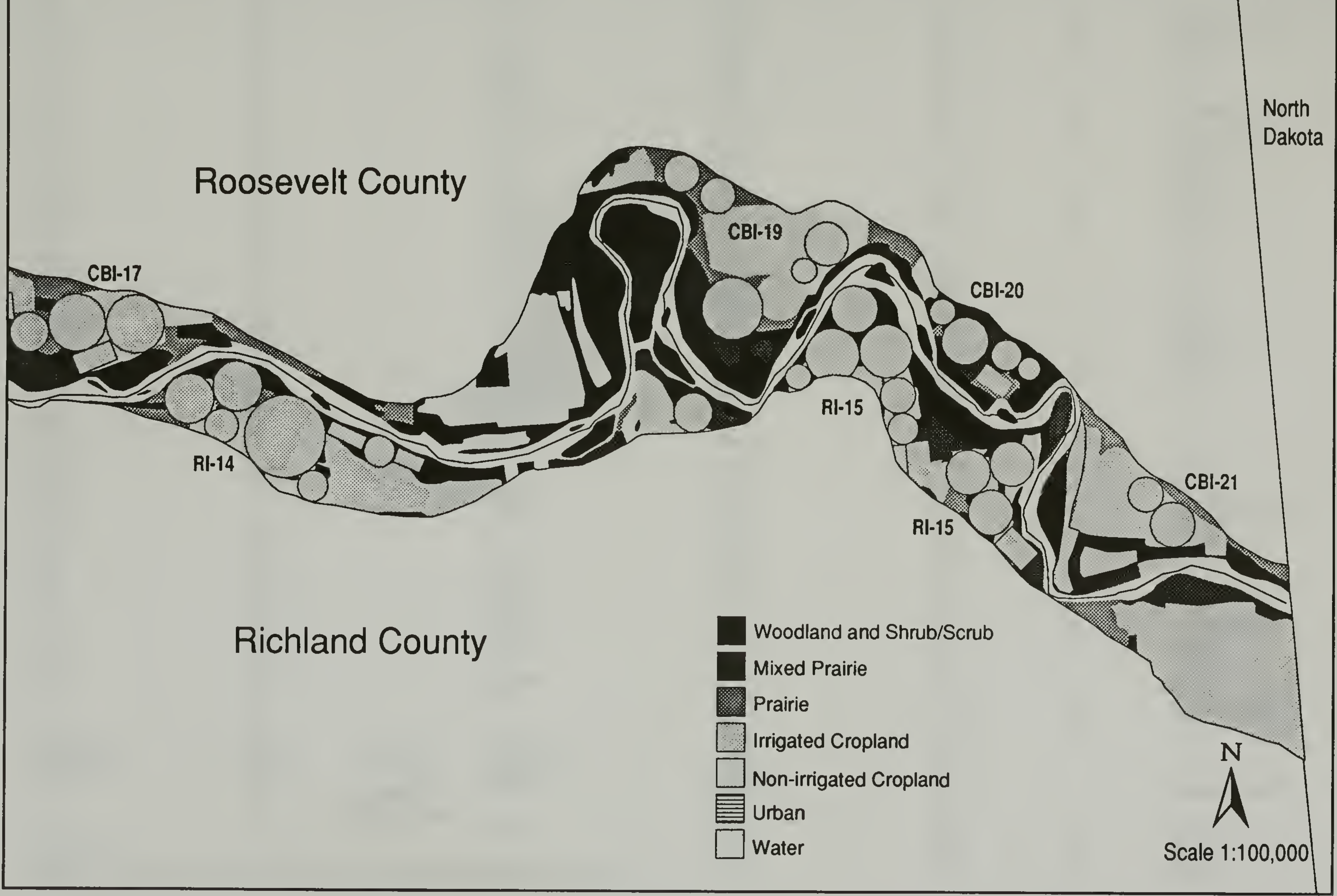


Table F-1. Projects affecting wetlands in the Sheridan County Groundwater Area

| PROJECT NUMBER | Project Acres | Approximate Wetland Area (acres)[a] | Wetland Type[b] |
|---|---|---|---|
| 2.1 | 146 | | —[c] |
| 3.1 | 154 | 1 | PEMC |
| 4.1 | 154 | | — |
| 4.2 | 100 | 1 | PEMA |
| 6.1 | 154 | 1 | PEMC |
| 8.1 | 154 | 1 | PEMC |
| 9.1 | 105 | 4 | PEMC |
| 9.2 | 154 | | — |
| 10.1 | 154 | | — |
| 10.2 | 154 | 2 | PEMA |
| 11.1 | 110 | | — |
| 11.2 | 225 | | — |
| 11.3 | 185 | | — |
| 11.4 | 187 | | PEMF |
| 11.5 | 105 | | — |
| 11.6 | 135 | 5 | PEMC |
| 14.1 | 129 | 4 | PEMF,PEMC |
| 14.2 | 130 | 1 | PEMC,PEMA |
| 14.3 | 165 | | — |
| 14.4 | 165 | 7 | PEMA |
| 14.5 | 225 | 1 | PEMA |
| 14.6 | 80 | | — |
| 14.7 | 154 | 7 | PEMC,PEMA |
| 14.8 | 154 | 9 | PEMA,PEMC |
| 14.9 | 160 | 27 | PEMF,PEMC |
| 15.1 | 154 | | — |
| 15.2 | 148 | | — |
| 15.3 | 154 | 1 | PEMA |
| 17.1 | 110 | | — |
| 17.2 | 100 | 1 | PEMA |
| 18.1 | 154 | 1 | PEMA |
| 18.2 | 154 | 1 | PABFx |
| 19.1 | 154 | | — |
| 19.2 | 40 | | — |
| 20.1 | 135 | 1 | PEMC |
| 20.2 | 156 | 1 | PEMC |
| 20.3 | 165 | 6 | PEMC,PEMA |
| 21.1 | 160 | | — |
| 21.2 | 110 | | — |
| 21.3 | 160 | 1 | PEMA |
| 22.1 | 154 | 2 | PEMC,PEMA |
| 22.2 | 154 | 5 | PEMF |
| 22.5 | NA | | |
| 23.1 | 170 | 8 | PABF, PEMC, PEMA |
| 23.2 | 138 | | — |
| 23.3 | 80 | | — |
| 23.4 | 154 | 3 | PEMA,PEMC |
| 23.5 | 176 | 5 | PEMA, |
| 26.1 | 154 | | — |
| 28.1 | 147 | 4 | PEMC |
| 28.2 | 148 | 2 | PEMC,PEMA |
| 28.3 | 150 | | — |
| 30.1 | 147 | | — |
| 30.2 | 148 | 1 | PEMA |
| 30.3 | 154 | 1 | PEMC |
| 30.4 | 148 | 4 | PEMC,PEMA |
| 30.5 | 154 | 1 | PEMC,PEMA |
| 30.6 | 154 | 3 | PEMC |
| 30.7 | 154 | 1 | PEMA |
| 30.8 | 154 | | — |
| 30.9 | 154 | | — |
| 30.10 | 129 | | — |
| 32.1 | 160 | 8 | PEMA |
| 32.2 | 160 | 2 | PEMC |
| 32.3 | 75 | 3 | PEMF,PEMC |
| 33.1 | 160 | | — |
| 34.1 | 154 | 1 | PEMC |
| 34.2 | 154 | | — |
| 34.3 | 154 | 1 | PEMC |
| 35.1 | 154 | | — |
| 36.1 | 154 | 1 | PEMA |
| 37.1 | 155 | 3 | PEMC |
| 38.1 | 154 | 1 | PEMA |
| 38.2 | 154 | 1 | PEMA |
| 38.3 | 147 | 1 | PEMA |
| 39.1 | 80 | 13 | PEMA,PEMF |
| 39.2 | 154 | | — |
| 39.3 | 148 | | — |
| 39.4 | 154 | 1 | PEMA |
| 39.5 | 148 | 4 | PEMF, PEMC |
| 39.6 | 148 | | — |
| 40.1 | 154 | | — |
| 40.2 | 146 | | — |
| 40.3 | 148 | | — |
| 40.4 | 115 | 1 | PEMC |
| 42.1 | 160 | | — |

| | | | |
|---|---|---|---|
| 42.2 | 154 | | — |
| 42.3 | 154 | 1 | PEMA |
| 42.4 | 160 | | — |
| 42.5 | 110 | | — |
| 44.1 | 154 | | — |
| 44.2 | 154 | | — |
| 44.3 | 137 | | — |
| 45.1 | 125 | 7 | PEMC |
| 45.2 | 154 | | — |
| 45.3 | 154 | 2 | PEMC |
| 47.1 | 154 | | — |
| 47.2 | 154 | 2 | PEMC,PEMA |
| 47.3 | 80 | | — |
| 47.4 | 240 | 3 | PEMC |
| 47.5 | 120 | 1 | PEMC |
| 54.1 | 154 | | — |
| 57.1 | 154 | 1 | PEMC |
| 58.1 | 154 | 7 | PEMC,PEMA |
| 59.1 | 155 | 1 | PEMA,PEMC |
| 59.2 | 138 | | — |
| 59.3 | 146 | | — |
| 59.4 | 154 | 1 | PEMC |
| 59.5 | 147 | | — |
| 59.6 | 147 | 1 | PEMC |
| 59.9 | NA | | |
| 62.1 | 80 | | — |
| 62.2 | 170 | 7 | PEMC |
| 62.3 | 148 | | — |
| 62.4 | 154 | 10 | PEMA |
| 62.5 | 125 | 2 | PEMAA |
| 62.6 | 95 | | — |
| 63.1 | 154 | | — |
| 64.1 | 144 | | — |
| 64.2 | 144 | | — |
| 64.3 | 154 | 3 | PEMC |
| 67.1 | 148 | | — |
| 68.1 | 185 | | — |
| 68.2 | 110 | | — |
| 68.3 | 165 | 1 | PEMA |
| 71.1 | 95 | | — |
| 71.2 | 182 | | — |
| 73.1 | 80 | | — |
| 73.2 | 135 | 8 | PEMF |
| 73.3 | 130 | 1 | PEMC |
| 75.1 | 154 | | — |
| 75.2 | 154 | 2 | PEMA |
| 75.3 | 154 | | — |
| 75.4 | 45 | 1 | PEMF |
| 77.1 | 154 | | — |
| 78.1 | 160 | | — |
| 78.2 | 154 | 1 | PEMC |
| 78.3 | 154 | 2 | PEMC |
| 81.1 | 154 | | — |
| 81.2 | 154 | 3 | PEMC,PEMA |
| 81.3 | 148 | 2 | PEMC |
| 81.4 | 154 | | — |
| 81.5 | 70 | 3 | PEMA |
| 82.1 | 150 | | — |
| 82.2 | 160 | 1 | PEMA |
| 82.3 | 154 | 4 | PEMC, PEMA |
| 83.1 | 154 | 1 | PEMC,PEMA |
| 84.1 | 120 | 1 | PEMC |
| 84.2 | 80 | | — |
| 85.1 | 128 | 3 | PEMA |
| 85.2 | 130 | 11 | PEMA |
| 85.3 | 120 | | — |
| 85.4 | 140 | | — |
| 85.5 | 147 | 1 | PEMA |
| 85.6 | 147 | 5 | PEMA |
| 85.7 | 154 | 3 | PEMC |
| 85.8 | 140 | 3 | PEMA |
| 85.9 | 154 | 14 | PEMC |
| 85.10 | 120 | | — |
| 85.11 | 65 | | — |
| 85.12 | 80 | | — |
| 85.13 | 154 | 1 | PEMC |
| 86.1 | 165 | 2 | PEMA |
| 87.1 | 100 | | — |
| 87.2 | 100 | | — |
| 88.1 | 154 | 1 | PEMC |
| 88.2 | 110 | 1 | PEMA |
| 88.3 | 154 | 4 | PEMC |
| 89.1 | 165 | 1 | PEMC |
| 89.2 | 130 | 2 | PEMC |
| 90.1 | 170 | 2 | PEMC |
| 90.2 | 154 | 8 | PEMC |
| 90.3 | 154 | 3 | PEMC |
| 90.4 | 154 | 1 | PEMC |
| 90.5 | 170 | 6 | PEMC,PEMAA |
| 90.6 | 130 | | — |
| 90.7 | 154 | 8 | PEMC,PEMA |
| 92.1 | 150 | 9 | PEMA,PEMC |
| 94.1 | 64 | | — |
| 94.2 | 120 | | — |
| 94.3 | 165 | 3 | PEMA |
| 94.4 | 154 | 1 | PEMA |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100.1 | 154 | | — | 131.2 | 128 | 1 | PEMA,PEMC |
| 100.2 | 154 | | — | 133.1 | 138 | 11 | PEMF |
| 100.3 | 154 | 1 | PEMC | 133.2 | 142 | 2 | — |
| 100.4 | 65 | | — | 133.3 | 148 | 1 | PEMA, PEMC |
| 100.5 | 129 | | — | 134.1 | 58 | | — |
| 103.1 | 154 | | — | 134.2 | 90 | | — |
| 103.2 | 125 | 1 | PEMF | 134.3 | 179 | 1 | PEMC |
| 104.1 | 140 | | — | 134.4 | 160 | | PEMA |
| 105.1 | 154 | 2 | PEMA | 135.1 | 154 | | — |
| 105.2 | 92 | | — | 135.2 | 100 | 11 | PEMC |
| 105.3 | 154 | 1 | PEMC | 135.3 | 80 | | — |
| 105.4 | 128 | | — | 135.4 | 154 | | — |
| 105.5 | 154 | 2 | PEMA,PEMC | 135.5 | 137 | 2 | PEMA |
| 105.6 | 80 | 6 | PEMA | 135.6 | 120 | 10 | PEMC |
| 106.1 | 70 | 2 | PEMA | 137.1 | 154 | | — |
| 106.2 | 147 | 6 | PEMC,PEMA | 138.1 | 160 | 2 | PEMC |
| 106.3 | 116 | 6 | PEMC | 138.2 | 154 | 8 | PEMC |
| 108.1 | 154 | 35 | PEMC, PEMA | 138.3 | 200 | 1 | PEMC |
| 110.1 | 154 | 10 | PEMF | 143.1 | 154 | 2 | PEMA |
| 112.1 | 154 | | — | 143.2 | 148 | 2 | PEMA |
| 112.2 | 147 | | — | 143.3 | 154 | 8 | PEMC,PEMA |
| 112.3 | 110 | | — | 144.1 | 75 | | — |
| 115.1 | 165 | | — | 145.1 | 86 | | — |
| 116.1 | 154 | | — | 145.2 | 101 | | — |
| 116.2 | 170 | | — | 145.3 | 138 | 1 | PEMA |
| 116.3 | 129 | | — | 146.1 | 148 | | — |
| 116.4 | 130 | | — | 146.2 | 138 | | — |
| 118.1 | 135 | | — | 147.1 | 120 | 3 | PEMF, PEMC |
| 118.2 | 120 | | — | 148.1 | 170 | 12 | PEMC,PEMA |
| 118.3 | 100 | 2 | PEMA | 148.2 | 154 | 2 | PEMA |
| 122.1 | 147 | | — TWO ON MAP | 148.3 | 148 | 14 | PEMC |
| 122.2 | 154 | | NOT ON MAP | 150.1 | 146 | 1 | PEMA,PEMC |
| 123.1 | 148 | | — | 150.2 | 162 | | — |
| 123.2 | 148 | | — | 151.1 | 154 | 1 | PEMA |
| 124.1 | 154 | | — | 151.2 | 154 | 2 | PEMC |
| 124.2 | 154 | | — | 152.1 | 80 | 24 | PEMA |
| 124.3 | 154 | | — | 155.1 | 75 | | — |
| 124.4 | 154 | | — | 156.1 | 154 | | — |
| 127.1 | 130 | | — | 156.2 | 75 | | — |
| 127.2 | 118 | 2 | PEMA | 156.3 | 80 | 2 | PEMF |
| 129.1 | 146 | 1 | PEMA | 157.1 | 148 | 1 | PEMA |
| 129.2 | 140 | 5 | — | 157.2 | 116 | 19 | PEMC |
| 129.3 | 128 | 1 | PEMA,PEMC | 159.1 | 120 | | — |
| 130.1 | 145 | 2 | PABF | 160.1 | 78 | | — |
| 130.2 | 160 | 1 | PEMC | 161.1 | 154 | | — |
| 130.3 | 154 | | — | 161.2 | 80 | 2 | PEMC,PEMA |
| 130.4 | 135 | | — | 162.1 | 113 | | — |
| 131.1 | 154 | 12 | PEMC | 163.1 | 80 | | — |

| | | | |
|---|---|---|---|
| 163.2 | 60 | 3 | PEMA,PEMC |
| 164.1 | 137 | 1 | PEMA |
| 165.1 | 137 | 1 | PEMC |
| 165.2 | 120 | 2 | PEMC |
| 166.1 | 156 | | — |
| 166.2 | 135 | | — |
| 168.1 | 154 | | — |
| 170.1 | 148 | 1 | PEMC |
| 170.2 | 154 | 5 | PEMC |
| 171.1 | 83 | | — |
| 171.2 | 92 | 2 | PEMC |
| 176.1 | 154 | | — |
| 177.1 | 135 | 8 | PEMC |
| 179.1 | 154 | | — |
| 179.2 | 154 | | — |
| 179.3 | 154 | | — |
| 179.4 | 154 | | — |
| 179.5 | 154 | | — |
| 179.6 | 154 | | — |
| 179.7 | 154 | | — |
| 179.8 | 154 | | — |
| 179.9 | 154 | | — |
| 179.10 | 154 | | — |
| 179.11 | 154 | | — |
| 179.12 | 154 | | — |
| 179.13 | 154 | 1 | PEMC |
| 179.14 | 154 | 1 | PEMA |
| 179.15 | 115 | | — |
| 180.1 | 154 | 1 | PEMC |
| 180.2 | 138 | | — |

[a] acreages less than one acre are listed as one acre

[b] Wetlands were classified based on the Cowardin System (Cowardin et al. 1979). The system
as it applies to these wetlands is coded as follows:
System (first letter):
Palustrine (P) - vegetated non-tidal wetlands
Classes (second and third letters):
Aquatic Bed (AB) - contains beds of aquatic plants
Emergent (EM) - dominated by non-woody plants
Forested (FO)
Scrub-shrub (SS)
Unconsolidated shore (US) - river shorelines
Water Regime (fourth letter)
Temporarily flooded (A) - only flooded for brief periods most years
Seasonally flooded (c) - flooded seasonally for more extended periods
Modifers (fifth letter , if present)
Excavated (x)

[c] — means that no wetlands are known to occur on project lands

source: USFWS 1989 and undated

# APPENDIX G

## EXISTING LAND USE WHERE IRRIGATION PROJECTS ARE PROPOSED

Table G–1. Existing land use on lands proposed for irrigation projects (acres)

| Conservation District/ Project | Project Size | Existing Irrigation | Dryland Grain | Dryland Hay | Dryland Range | Riparian Range |
|---|---|---|---|---|---|---|
| BLAINE | | | | | | |
| BL–131 | 70 | | 70 | | 23 | 27 |
| BL–171 | 71 | | | | 83 | 55 |
| BL–181 | 6000 | 6000 | | | 577 | 955 |
| CARTER | | | | | | |
| CT–011 | 157 | | 33 | | 121 | 3 |
| CT–012WS | 173 | | | 90 | 83 | |
| CT–041WS | 130 | | | | 130 | |
| CT–071 | 80 | | | | 80 | |
| CT–121 | 94 | | 94 | | | |
| CT–122WS | 60 | | 60 | | | |
| CT–131 | 88 | | | | 86 | 2 |
| CT–141WS | 80 | | | | 80 | |
| CT–151WS | 36 | | | | 36 | |
| CT–152WS | 11 | | | | 11 | |
| CT–153WS | 56 | | | | 56 | |
| CT–154WS | 9 | | | | 9 | |
| CT–161WS | 28 | | | | 28 | |
| CT–162WS | 33 | | | | 33 | |
| CT–171WS | 110 | | | | 95 | 15 |
| CT–181WS | 150 | | | | 150 | |
| CT–191 | 91 | | | | 88 | 3 |
| CT–221 | 115 | | | 115 | | |
| CT–241 | 99 | | | | 99 | |
| CT–243WS | 6 | | | | 6 | |
| CT–244WS | 70 | | | | 70 | |
| CT–251 | 107 | | | | 107 | |
| CT–261WS | 13 | | | | 13 | |
| CT–262WS | 2 | | | | 2 | |
| CT–291WS | 20 | | | | 20 | |
| CT–293WS | 5 | | | | 4 | 1 |
| CT–294 | 22 | | 22 | | | |
| CT–301WS | 260 | | | 260 | | |
| CT–310WS | 30 | | | | 30 | |
| CT–320 | 17 | | | 17 | | |
| CT–340WS | 115 | | | | 113 | 2 |
| CT–370 | 39 | | 39 | | | |
| CT–380 | 13 | | | 13 | | |

| Conservation District/ Project | Project Size | Existing Irrigation | Dryland Grain | Dryland Hay | Dryland Range | Riparian Range |
|---|---|---|---|---|---|---|
| DANIELS | | | | | | |
| DA–21WS | 25 | | | | 25 | |
| DA–31 | 89 | | 80 | | 9 | |
| DA–32 | 40 | | 40 | | | |
| DA–51 | 25 | | 25 | | | |
| DA–71 | 215 | | | | | 215 |
| DA–131WS | 81 | | 81 | | | |
| DA–151 | 135 | | 135 | | | |
| DA–152WS | 6 | | | | 6 | |
| DA–153WS | 79 | | 79 | | | |
| DA–161 | 11 | | | 11 | | |
| DA–181WS | 80 | | 61 | | 7 | 12 |
| DA–182WS | 30 | | | | 30 | |
| DA–211 | 35 | | | | 23 | 12 |
| DA–221 | 137 | | | | | 137 |
| DA–251 | 41 | | 32 | | 9 | |
| DA–252 | 67 | | 67 | | | |
| DA–261 | 66 | | 57 | | 9 | |
| DA–281 | 87 | | 41 | | 46 | |
| DA–291WS | 152 | | 115 | | 37 | |
| DA–341 | 36 | | | | 36 | |
| DA–371WS | 2 | | | | 2 | |
| LIBERTY | | | | | | |
| LI–241 | 50 | | 50 | | 45 | 10 |
| LITTLE BEAVER | | | | | | |
| LB–011WS | 77 | | 51 | | 24 | 2 |
| LB–041WS | 16 | | | | 13 | 3 |
| LB–061WS | 60 | | | | 45 | 15 |
| LB–063WS | 9 | | | | 9 | |
| LB–083WS | 50 | | | | 45 | 5 |
| LB–121WS | 97 | | 87 | | | 10 |
| LB–141WS | 145 | | 4 | | 141 | |
| LB–151WS | 76 | | 10 | | 59 | 7 |
| LB–161WS | 272 | | 84 | | 161 | 27 |
| LB–171WS | 30 | | 25 | | 2 | 3 |
| LB–172WS | 12 | | | | 11 | 1 |
| LB–181WS | 11 | | | | 11 | |
| LB–182WS | 25 | | | | 25 | |
| LB–191WS | 150 | | | 109 | 41 | |

| Conservation District/ Project | Project Size | Existing Irrigation | Dryland Grain | Dryland Hay | Dryland Range | Riparian Range |
|---|---|---|---|---|---|---|
| McCONE | | | | | | |
| MC–01 | 214 | | 155 | | | 59 |
| MC–03 | 346 | | 333 | | | 13 |
| MC–04 | 114 | | | 32 | | 82 |
| MC–05 | 298 | | 236 | | | 62 |
| MC–5A | 367 | | 30 | | | 337 |
| MC–06 | 298 | | | 28 | 26 | 244 |
| MC–6A | 111 | | | 38 | | 73 |
| MC–08 | 1279 | | | 929 | 159 | 191 |
| MC–09 | 342 | | | 5 | 281 | 56 |
| MC–9A | 25 | 18 | | | | 7 |
| MC–10 | 349 | | 310 | | | 39 |
| MC–11 | 911 | | 645 | | | 266 |
| MC–12 | 536 | | 223 | | 313 | |
| MC–99 | 934 | 125 | 440 | | 97 | 272 |
| RICHLAND | | | | | | |
| RI–01 | 1550 | | 1147 | 30 | | 373 |
| RI–02 | 278 | | 115 | | | 163 |
| RI–03 | 810 | | | 75 | | 735 |
| RI–04 | 202 | | 156 | 46 | | |
| RI–05 | 526 | 247 | 127 | 12 | | 140 |
| RI–06 | 416 | 153 | | | | 263 |
| RI–07 | 1029 | 292 | 647 | | | 90 |
| RI–08 | 277 | | 277 | | | |
| RI–09 | 935 | 311 | 380 | 79 | | 165 |
| RI–10 | 643 | | 243 | 109 | | 291 |
| RI–11A | 189 | 11 | 168 | | | 10 |
| RI–11 | 686 | 33 | 53 | 147 | | 453 |
| RI–12 | 782 | | 368 | 56 | | 358 |
| RI–13 | 399 | | 42 | 14 | | 343 |
| RI–14 | 1003 | | 534 | | | 469 |
| RI–15 | 1416 | | 658 | | | 758 |
| ROOSEVELT | | | | | | |
| CBI–1 | 715 | 78 | 635 | | | 2 |
| CBI–2 | 1065 | | 963 | | | 102 |
| CBI–3 | 1817 | | 1806 | | | 11 |
| CBI–4 | 898 | | 857 | | | 41 |
| CBI–5 | 182 | 20 | 162 | | | |

| Conservation District/ Project | Project Size | Existing Irrigation | Dryland Grain | Dryland Hay | Dryland Range | Riparian Range |
|---|---|---|---|---|---|---|
| CBI–6 | 258 | | | 138 | | 120 |
| CBI–7 | 784 | 25 | 741 | | | 18 |
| CBI–8 | 164 | | 123 | 22 | | 19 |
| CBI–9 | 238 | | 238 | | | |
| CBI–10 | 770 | | 635 | 14 | | 121 |
| CBI–11 | 1640 | 258 | 1357 | | | 25 |
| CBI–12 | 1448 | 69 | 1331 | | | 48 |
| CBI–13 | 9175 | | 8755 | | 362 | 58 |
| CBI–14 | 291 | | 236 | | 8 | 47 |
| CBI–15 | 618 | | 352 | 17 | | 249 |
| CBI–16 | 1114 | | 1098 | | 12 | 4 |
| CBI–17 | 627 | | 129 | 240 | | 258 |
| CBI–18 | 1592 | | 1592 | | | |
| CBI–19 | 549 | 22 | 152 | | | 375 |
| CBI–20 | 262 | | | | | 262 |
| CBI–21 | 464 | | | | | 464 |
| VALLEY | | | | | | |
| VA–01 | 75 | 53 | 22 | | | |
| VA–02 | 995 | | 995 | | | |
| VA–03 | 933 | | 599 | | | 334 |
| VA–71 | 253 | 162 | 48 | | 11 | 32 |
| VA–171 | 144 | | 144 | | | |
| VA–211 | 98 | 66 | | | | 32 |
| VA–231 | 320 | 120 | 185 | | | 15 |
| VA–261 | 157 | | 31 | 89 | | 37 |
| VA–291 | 151 | | 151 | | | |
| VA–521 | 124 | | 113 | | | 11 |
| WIBAUX | | | | | | |
| WI–41WS | 26 | | 26 | | | |
| WI–42WS | 101 | | 99 | | | 2 |
| WI–43WS | 74 | | | | 74 | |
| WI–61WS | 12 | | 6 | | 6 | |
| WI–71WS | 14 | | | | 14 | |
| WI–72WS | 8 | | | | 8 | |
| WI–73WS | 100 | | | 100 | | |
| WI–74WS | 63 | | 49 | | 14 | |
| WI–75WS | 58 | | 49 | | 9 | |
| WI–91WS | 50 | | | 50 | | |
| WI–92WS | 52 | | 44 | | | 8 |

| Conservation District/ Project | Project Size | Existing Irrigation | Dryland Grain | Dryland Hay | Dryland Range | Riparian Range |
|---|---|---|---|---|---|---|
| WI–93WS | 6 | | | | 6 | |
| WI–121WS | 27 | | | | 27 | |
| WI–151WS | 80 | | 38 | | 42 | |
| WI–161WS | 22 | | 22 | | | |
| WI–162WS | 6 | | 6 | | | |
| WI–171WS | 25 | | 22 | | | 3 |
| WI–181WS | 60 | | 60 | | | |
| WI–191WS | 25 | | 17 | | | 8 |
| WI–192WS | 10 | | 10 | | | |
| WI–201WS | 73 | | 22 | | 51 | |
| WI–202WS | 44 | | | | 18 | 26 |
| WI–211WS | 29 | | | | 29 | |
| WI–221WS | 7 | | 7 | | | |
| WI–232WS | 21 | | 9 | | 9 | 3 |
| WI–233WS | 19 | | | | 19 | |
| WI–234WS | 65 | | | | 65 | |
| WI–235WS | 26 | | | | 26 | |
| WI–236WS | 39 | | 34 | | 5 | |
| WI–237WS | 32 | | 32 | | | |
| SHERIDAN | | | | | | |
| 2.1 | 146 | | 146 | | | |
| 3.1 | 154 | | 153 | | | 1 |
| 4.1 | 154 | | 154 | | | |
| 4.2 | 100 | | 53 | 46 | | 1 |
| 6.1 | 154 | | 144 | 9 | | 1 |
| 8.1 | 154 | | 153 | | | 1 |
| 9.1 | 105 | | 101 | | | 4 |
| 9.2 | 154 | | 154 | | | |
| 10.1 | 154 | | 154 | | | |
| 10.2 | 154 | | 152 | | | 2 |
| 11.1 | 110 | | | 110 | | |
| 11.2 | 225 | | 183 | 42 | | |
| 11.3 | 185 | | 179 | 6 | | |
| 11.4 | 187 | | 187 | | | |
| 11.5 | 105 | | | 105 | | |
| 11.6 | 135 | | | 130 | | 5 |
| 14.1 | 129 | | 125 | | | 4 |
| 14.2 | 130 | | 129 | | | 1 |
| 14.3 | 165 | | 165 | | | |
| 14.4 | 165 | | 158 | | | 7 |
| 14.5 | 225 | | 225 | | | |

| Conservation District/ Project | Project Size | Existing Irrigation | Dryland Grain | Dryland Hay | Dryland Range | Riparian Range |
|---|---|---|---|---|---|---|
| SHERIDAN | | | | | | |
| 14.6 | 80 | | 80 | | | |
| 14.7 | 154 | | 147 | | | 7 |
| 14.8 | 154 | | 145 | | | 9 |
| 14.9 | 160 | | 133 | | | 27 |
| 15.1 | 154 | | 122 | 32 | | |
| 15.2 | 148 | | 148 | | | |
| 15.3 | 154 | | 153 | | | 1 |
| 17.1 | 110 | | 110 | | | |
| 17.2 | 100 | | 99 | | | 1 |
| 18.1 | 154 | | 153 | | | 1 |
| 18.2 | 154 | | 154 | | | |
| 19.1 | 154 | | 130 | 24 | | |
| 19.2 | 40 | | | 40 | | |
| 20.1 | 135 | | 134 | | | 1 |
| 20.2 | 156 | | 155 | | | 1 |
| 20.3 | 165 | | 159 | | | 6 |
| 21.1 | 160 | | 160 | | | |
| 21.2 | 110 | | 110 | | | |
| 21.3 | 160 | | 91 | 68 | | 1 |
| 22.1 | 154 | | 152 | | | 2 |
| 22.2 | 154 | | 149 | | | 5 |
| 22.5 | NA | | | | | |
| 23.1 | 170 | | 162 | | | 8 |
| 23.2 | 138 | | 138 | | | |
| 23.3 | 80 | | 80 | | | |
| 23.4 | 154 | | 151 | | | 3 |
| 23.5 | 176 | | 171 | | | 5 |
| 26.1 | 154 | | | 154 | | |
| 28.1 | 147 | | 143 | | | 4 |
| 28.2 | 148 | | 146 | | | 2 |
| 28.3 | 150 | | 142 | | | 8 |
| 30.1 | 147 | | 140 | | | 7 |
| 30.2 | 148 | | 144 | | | 4 |
| 30.3 | 154 | | 154 | | | |
| 30.4 | 148 | | 144 | | | 4 |
| 30.5 | 154 | | 153 | | | 1 |
| 30.6 | 154 | | 151 | | | 3 |
| 30.7 | 154 | | 154 | | | |
| 30.8 | 154 | | 154 | | | |
| 30.9 | 154 | | 154 | | | |
| 30.10 | 129 | | 129 | | | |
| 32.1 | 160 | | 83 | 62 | | 15 |

| Conservation District/ Project | Project Size | Existing Irrigation | Dryland Grain | Dryland Hay | Dryland Range | Riparian Range |
|---|---|---|---|---|---|---|
| Sheridan | | | | | | |
| 32.2 | 160 | | 107 | 38 | | 15 |
| 32.3 | 75 | | 72 | | | 3 |
| 33.1 | 160 | | 160 | | | |
| 34.1 | 154 | | | 153 | | 1 |
| 34.2 | 154 | | 154 | | | |
| 34.3 | 154 | | 145 | | | 9 |
| 35.1 | 154 | | 154 | | | |
| 36.1 | 154 | | 153 | | | 1 |
| 37.1 | 155 | | | 152 | | 3 |
| 38.1 | 154 | | 153 | | | 1 |
| 38.2 | 154 | | 153 | | | 1 |
| 38.3 | 147 | | 66 | 80 | | 1 |
| 39.1 | 80 | | 63 | 4 | | 13 |
| 39.2 | 154 | | 154 | | | |
| 39.3 | 148 | | 148 | | | |
| 39.4 | 154 | | 153 | | | 1 |
| 39.5 | 148 | | 144 | | | 4 |
| 39.6 | 148 | | 138 | | | 10 |
| 40.1 | 154 | | 151 | | | 3 |
| 40.2 | 146 | | 141 | | | 5 |
| 40.3 | 148 | | 133 | 15 | | |
| 40.4 | 115 | | 99 | | | 16 |
| 42.1 | 160 | | 160 | | | |
| 42.2 | 154 | | 154 | | | |
| 42.3 | 154 | | 153 | | | 1 |
| 42.4 | 160 | | | 160 | | |
| 42.5 | 110 | | 110 | | | |
| 44.1 | 154 | | 154 | | | |
| 44.2 | 154 | | 154 | | | |
| 44.3 | 137 | | 118 | 19 | | |
| 45.1 | 125 | | 103 | | | 22 |
| 45.2 | 154 | | 154 | | | |
| 45.3 | 154 | 152 | | | | 2 |
| 47.1 | 154 | | 77 | 77 | | |
| 47.2 | 154 | | | 152 | | 2 |
| 47.3 | 80 | | 80 | | | |
| 47.4 | 240 | | | 237 | | 3 |
| 47.5 | 120 | | | 119 | | 1 |
| 54.1 | 154 | | 154 | | | |
| 57.1 | 154 | | 153 | | | 1 |
| 58.1 | 154 | | 147 | | | 7 |
| 59.1 | 155 | | 154 | | | 1 |

| Conservation District/ Project | Project Size | Existing Irrigation | Dryland Grain | Dryland Hay | Dryland Range | Riparian Range |
|---|---|---|---|---|---|---|
| SHERIDAN | | | | | | |
| 59.2 | 138 | | 138 | | | |
| 59.3 | 146 | | 146 | | | |
| 59.4 | 154 | 153 | | | | 1 |
| 59.5 | 147 | | 107 | 40 | | |
| 59.6 | 147 | | | 147 | | |
| 59.9 | NA | | | | | |
| 62.1 | 80 | | | 80 | | |
| 62.2 | 170 | | 87 | 76 | | 7 |
| 62.3 | 148 | | 139 | | | 9 |
| 62.4 | 154 | | 144 | | | 10 |
| 62.5 | 125 | | 123 | | | 2 |
| 62.6 | 95 | | 95 | | | |
| 63.1 | 154 | | 154 | | | |
| 64.1 | 144 | | 144 | | | |
| 64.2 | 144 | | 144 | | | |
| 64.3 | 154 | | 151 | | | 3 |
| 67.1 | 148 | | 148 | | | |
| 68.1 | 185 | | 185 | | | |
| 68.2 | 110 | | 110 | | | |
| 68.3 | 165 | | 164 | | | 1 |
| 71.1 | 95 | | 95 | | | |
| 71.2 | 182 | | 182 | | | |
| 73.1 | 80 | | 80 | | | |
| 73.2 | 135 | | 127 | | | 8 |
| 73.3 | 130 | | 127 | 3 | | |
| 75.1 | 154 | | 154 | | | |
| 75.2 | 154 | | 152 | | | 2 |
| 75.3 | 154 | | 154 | | | |
| 75.4 | 45 | | 44 | | | 1 |
| 77.1 | 154 | | 154 | | | |
| 78.1 | 160 | | 147 | | | 13 |
| 78.2 | 154 | | 50 | 103 | | 1 |
| 78.3 | 154 | | 152 | | | 2 |
| 81.1 | 154 | | 154 | | | |
| 81.2 | 154 | | 151 | | | 3 |
| 81.3 | 148 | | 134 | 12 | | 2 |
| 81.4 | 154 | | 154 | | | |
| 81.5 | 70 | | 54 | 13 | | 3 |
| 82.1 | 150 | | 150 | | | |
| 82.2 | 160 | | 159 | | | 1 |
| 82.3 | 154 | | 148 | | | 6 |
| 83.1 | 154 | | 148 | | | 6 |

| Conservation District/ Project | Project Size | Existing Irrigation | Dryland Grain | Dryland Hay | Dryland Range | Riparian Range |
|---|---|---|---|---|---|---|
| SHERIDAN | | | | | | |
| 84.1 | 120 | | 119 | | | 1 |
| 84.2 | 80 | | 63 | 15 | | 2 |
| 85.1 | 128 | | 125 | | | 3 |
| 85.2 | 130 | | | 119 | | 11 |
| 85.3 | 120 | | | 120 | | |
| 85.4 | 140 | | 140 | | | |
| 85.5 | 147 | | 146 | | | 1 |
| 85.6 | 147 | | 142 | | | 5 |
| 85.7 | 154 | | 151 | | | 3 |
| 85.8 | 140 | | 128 | | | 12 |
| 85.9 | 154 | | 140 | | | 14 |
| 85.10 | 120 | | 80 | 40 | | |
| 85.11 | 65 | | | 65 | | |
| 85.12 | 80 | | | 80 | | |
| 85.13 | 154 | | 154 | | | |
| 86.1 | 165 | | 136 | | | 29 |
| 87.1 | 100 | | 100 | | | |
| 87.2 | 100 | | 100 | | | |
| 88.1 | 154 | | 153 | | | 1 |
| 88.2 | 110 | | 102 | | | 8 |
| 88.3 | 154 | | 151 | | | 3 |
| 89.1 | 165 | | 164 | | | 1 |
| 89.2 | 130 | | 128 | | | 2 |
| 90.1 | 170 | | 168 | | | 2 |
| 90.2 | 154 | | 146 | | | 8 |
| 90.3 | 154 | | 63 | 88 | | 3 |
| 90.4 | 154 | | 143 | 10 | | 1 |
| 90.5 | 170 | | 164 | | | 6 |
| 90.6 | 130 | | 95 | 35 | | |
| 90.7 | 154 | | 146 | | | 8 |
| 92.1 | 150 | | 141 | | | 9 |
| 94.1 | 64 | | 63 | | | 1 |
| 94.2 | 120 | | 120 | | | |
| 94.3 | 165 | | 162 | | | 3 |
| 94.4 | 154 | | 154 | | | |
| 100.1 | 154 | | 154 | | | |
| 100.2 | 154 | | 154 | | | |
| 100.3 | 154 | | 153 | | | 1 |
| 100.4 | 65 | | 65 | | | |
| 100.5 | 129 | | 122 | | | 7 |
| 103.1 | 154 | | 154 | | | |
| 103.2 | 125 | | 117 | 7 | | 1 |

| Conservation District/ Project | Project Size | Existing Irrigation | Dryland Grain | Dryland Hay | Dryland Range | Riparian Range |
|---|---|---|---|---|---|---|
| SHERIDAN | | | | | | |
| 104.1 | 140 | | 137 | | | 3 |
| 105.1 | 154 | | 152 | | | 2 |
| 105.2 | 92 | | 92 | | | |
| 105.3 | 154 | | 153 | | | 1 |
| 105.4 | 128 | | 128 | | | |
| 105.5 | 154 | | 152 | | | 2 |
| 105.6 | 80 | | 74 | | | 6 |
| 106.1 | 70 | | | 68 | | 2 |
| 106.2 | 147 | | 141 | | | 6 |
| 106.3 | 116 | | 110 | | | 6 |
| 108.1 | 154 | | 119 | | | 35 |
| 110.1 | 154 | | 144 | | | 10 |
| 112.1 | 154 | | 154 | | | |
| 112.2 | 147 | | 147 | | | |
| 112.3 | 110 | | 110 | | | |
| 115.1 | 165 | | 143 | 22 | | |
| 116.1 | 154 | | 139 | 15 | | |
| 116.2 | 170 | | 170 | | | |
| 116.3 | 129 | | 129 | | | |
| 116.4 | 130 | | 130 | | | |
| 118.1 | 135 | | 128 | 7 | | |
| 118.2 | 120 | | 52 | 68 | | |
| 118.3 | 100 | | 33 | 65 | | 2 |
| 122.1 | 147 | | 147 | | | |
| 122.2 | 154 | | 154 | | | |
| 123.1 | 148 | | 145 | 3 | | |
| 123.2 | 148 | | 144 | | | 4 |
| 124.1 | 154 | | 154 | | | |
| 124.2 | 154 | | 154 | | | |
| 124.3 | 154 | | 154 | | | |
| 124.4 | 154 | | 154 | | | |
| 127.1 | 130 | | 130 | | | |
| 127.2 | 118 | | 116 | | | 2 |
| 129.1 | 146 | | 145 | | | 1 |
| 129.2 | 140 | | 135 | | | 5 |
| 129.3 | 128 | | 128 | | | |
| 130.1 | 145 | | 143 | | | 2 |
| 130.2 | 160 | | 159 | | | 1 |
| 130.3 | 154 | | 154 | | | |
| 130.4 | 135 | | 135 | | | |
| 131.1 | 154 | | 142 | | | 12 |
| 131.2 | 128 | | 127 | | | 1 |

| Conservation District/ Project | Project Size | Existing Irrigation | Dryland Grain | Dryland Hay | Dryland Range | Riparian Range |
|---|---|---|---|---|---|---|
| SHERIDAN | | | | | | |
| 133.1 | 138 | | 127 | | | 11 |
| 133.2 | 142 | | 140 | | | 2 |
| 133.3 | 148 | | 147 | | | 1 |
| 134.1 | 58 | | 53 | 5 | | |
| 134.2 | 90 | | 90 | | | |
| 134.3 | 179 | | 130 | 48 | | 1 |
| 134.4 | 160 | | 160 | | | |
| 135.1 | 154 | | 154 | | | |
| 135.2 | 100 | | 84 | 5 | | 11 |
| 135.3 | 80 | | 80 | | | |
| 135.4 | 154 | | 152 | | | 2 |
| 135.5 | 137 | | 135 | | | 2 |
| 135.6 | 120 | | 110 | | | 10 |
| 137.1 | 154 | 154 | | | | |
| 138.1 | 160 | | 158 | | | 2 |
| 138.2 | 154 | | 146 | | | 8 |
| 138.3 | 200 | | 182 | 17 | | 1 |
| 143.1 | 154 | | 152 | | | 2 |
| 143.2 | 148 | | 146 | | | 2 |
| 143.3 | 154 | | 146 | | | 8 |
| 144.1 | 75 | | 75 | | | |
| 145.1 | 86 | | 86 | | | |
| 145.2 | 101 | | 94 | | | 7 |
| 145.3 | 138 | | 137 | | | 1 |
| 146.1 | 148 | | 148 | | | |
| 146.2 | 138 | | 138 | | | |
| 147.1 | 120 | | | 120 | | |
| 148.1 | 170 | | 158 | | | 12 |
| 148.2 | 154 | | 152 | | | 2 |
| 148.3 | 148 | | 134 | | | 14 |
| 150.1 | 146 | | 145 | | | 1 |
| 150.2 | 162 | | 162 | | | |
| 151.1 | 154 | | 153 | | | 1 |
| 151.2 | 154 | | 152 | | | 2 |
| 152.1 | 80 | | 56 | | | 24 |
| 155.1 | 75 | | | 75 | | |
| 156.1 | 154 | | 154 | | | |
| 156.2 | 75 | | 75 | | | |
| 156.3 | 80 | | 78 | | | 2 |
| 157.1 | 148 | | 147 | | | 1 |
| 157.2 | 116 | | 97 | | | 19 |

| Conservation District/ Project | Project Size | Existing Irrigation | Dryland Grain | Dryland Hay | Dryland Range | Riparian Range |
|---|---|---|---|---|---|---|
| SHERIDAN | | | | | | |
| 159.1 | 120 | | 120 | | | |
| 160.1 | 78 | | 78 | | | |
| 161.1 | 154 | | 154 | | | |
| 161.2 | 80 | | 78 | | | 2 |
| 162.1 | 113 | | 113 | | | |
| 163.1 | 80 | | 59 | 21 | | |
| 163.2 | 60 | | 46 | 7 | | 7 |
| 164.1 | 137 | | 131 | 5 | | 1 |
| 165.1 | 137 | | 136 | | | 1 |
| 165.2 | 120 | | 118 | | | 2 |
| 166.1 | 156 | | 156 | | | |
| 166.2 | 135 | | 135 | | | |
| 168.1 | 154 | | 154 | | | |
| 170.1 | 148 | | 132 | 15 | | 1 |
| 170.2 | 154 | | 139 | 10 | | 5 |
| 171.1 | 83 | | 83 | | | |
| 171.2 | 92 | | 86 | 4 | | 2 |
| 176.1 | 154 | | 154 | | | |
| 177.1 | 135 | | 21 | 106 | | 8 |
| 179.1 | 154 | | 154 | | | |
| 179.2 | 154 | | 154 | | | |
| 179.3 | 154 | | 154 | | | |
| 179.4 | 154 | | 142 | | | 12 |
| 179.5 | 154 | | 154 | | | |
| 179.6 | 154 | | 154 | | | |
| 179.7 | 154 | | 154 | | | |
| 179.8 | 154 | | 154 | | | |
| 179.9 | 154 | | 154 | | | |
| 179.10 | 154 | | 154 | | | |
| 179.11 | 154 | | 154 | | | |
| 179.12 | 154 | | 154 | | | |
| 179.13 | 154 | | 153 | | | 1 |
| 179.14 | 154 | | 153 | | | 1 |
| 179.15 | 115 | | 115 | | | |
| 180.1 | 154 | | 154 | | | |
| 180.2 | 138 | | 133 | 5 | | |

Note: Existing land uses may not sum to project acres, since existing land uses also include proposed project storage areas. Projects that end in WS are water spreading projects.

# APPENDIX H

## FISHERIES VALUE CLASS AND RELATIVE FISH ABUNDANCE IN STREAMS WHERE DFWP HAS REQUESTED RESERVATIONS IN THE LOWER MISSOURI RIVER BASIN

## Table H-1. FISHERIES VALUE CLASS AND RELATIVE FISH ABUNDANCE IN STREAMS WHERE DFWP HAS REQUESTED RESERVATIONS IN THE LOWER MISSOURI RIVER BASIN

**Key to Symbols:**

1 = outstanding
2 = high value
3 = substantial
4 = moderate
5 = limited
6 = insufficient information to classify stream

A = abundent; C = common; P = present;
PE = prensence expected but not cnfirmed;
U = uncommon; R = rare

| FAMILY | | Sturgeon | | Paddlefish | Gar | Mooneye | Trout | | | | Pike | Minnow | | | | | | | | | | | | | | | | | Sucker | | | | | | | | Catfish | | | | Codfish | Killifish | Stickleback | Sunfish | | | | | Perch | | | | Drum | Sculpin | smelt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCIENTIFIC NAME | | *Scaphirhynchus albus* | *Scaphirhynchus playorynchus* | *Polydon spathula* | *Lepisosteus platostomus* | *Hiodon alosoides* | *Salmo gairdneri* | *Salmo trutta* | *Salvelinus fontinalis* | *Salvelinus namaycush* | *Esox lucius* | *Cyprinus carpio* | | *Notemigonous crysoleucas* | *Semotilus margarita* | *Semotilus atromaculatus* | *Phoxinus eos* | | *Hybopsis gracilis* | *Couesius plumbeus* | *Notropis atherinoides* | *Notropis stramineus* | *Hybognathus hankinsoni* | | *Hybognathus placitus* | *Hybognathus nuchalis* | *Pimephales Promelas* | *Rhinichthys cataractae* | *Carpiodes carpio* | *Cycleptus elongatus* | *Ictiobus bubalus* | *Ictiobus cyprinellus* | *Moxostoma macrolepidotum* | *Catostomus catostomus* | *Catostomus commersoni* | *Catostomus platyrhynchus* | *Ictalurus melas* | *Ictalurus natalis* | *Ictalurus punctatus* | *Noturus flavus* | *Lota lota* | *Fundulus kansae* | *Culaea inconstans* | *Lepomis cyanellus* | *Lepomis gibbosus* | *Lepomis macrochirus* | *Micropterus dolomieui* | *Pomoxis annularis* | *Perca flavescens* | *Stizostedion canadense* | *Stizostedion vitreum* | *Etheostoma exile* | *Aplodinotus grunniens* | *Cottus bairdi* | |
| COMMON NAME | Fisheries Resource Value Class | Pallid sturgeon | Shovelnose sturgeon | Paddlefish | Shortnose gar | Goldeye | Rainbow trout | Brown trout | Brook trout | Lake trout | Northern pike | Carp | Western silvery minnow | Golden shiner | Pearl dace | Creek chub | Northern redbelly dace | Northern redbelly/Finescale dace | Flathead chub | Lake chub | Emerald shiner | Sand shiner | Brassy minnow | Western plains/silvery minnow | Plains minnow | Silvery minnow | Fathead minnow | Longnose dace | River carpsucker | Blue sucker | Smallmouth buffalo | Bigmouth buffalo | Shorthead redhorse | Longnose sucker | White sucker | Mountain sucker | Black bullhead | Yellow bullhead | Channel catfish | Stonecat | Burbot | Plains killifish | Brook stickleback | Green sunfish | Pumpkinseed | Bluegill | Smallmouth bass | White crappie | Yellow perch | Sauger | Walleye | Iowa darter | Freshwater drum | Mottled sculpin | Rainbow smelt |
| **Milk River Subbasin** |||||||||||||||||||||||||||||||||||||||||||||||||||||||
| Battle Creek | 3 ||||||| PE || U |||||| C ||| C | U |||||| C | C |||||||| C || C ||| U | P || C |||||| U | P | P | C ||||
| Beaver Creek (Hill Co.) | 3 |||||| C | U | R || U |||||| C ||| C ||| U | U ||| U | C |||||| P | A | P | U ||||| U ||||||||| U || A ||
| Beaver Creek - Reach #1 (Phillips Co.) | 6 |||||||| P ||||||||||||||||||||||||||||||||||||||||||||||||
| Beaver Creek - Reach #2 (Phillips Co.) | 3 ||||| C ||||| U | C ||||| C || U | C ||| C | U ||| C | C | PE || U | U | C || C || C || P |||| U || U || P |||| P |||||
| Clear Creek | 4 |||||| C | C | A ||||||||||| P |||||| C | C |||||| P | C | P ||||||||||||||||| C ||
| Frenchman River | 3 ||||| U ||||| U | C ||||| C ||| C |||| C || C | P | A | C || P | P | C || C ||||| P ||| C |||| PE || C || U | P ||||
| Little Box Elder Creek | 4 |||||| R || C ||||||||| C | C |||| C || C | P | C |||||| C | A |||||||||||||||||| C ||
| Peoples Creek | 4 ||||| P | P || C |||||||| P ||| P | P |||| P | P | P | C ||| P | P | P | P | A | P ||||||| P |||||| P |||| P || C ||
| Rock Creek | 3 |||||||||| U | C ||||||| C | A | P |||| P | P | P | C | P |||| P || P | P || U |||||||||| U || P || U | C ||||
| **Lower Missouri River Subbasin** |||||||||||||||||||||||||||||||||||||||||||||||||||||||
| Missouri River - Reach #7 | 1 | R | A | A | R | A | R ||| C | C | A ||||| R || R | U | U || R | R ||| R | R | C | U | C | C | C | U | C || R || C | R | A || R || R |||| R | A | C | R | U || P |
| Missouri River - Reach #8 | 1 | R | A | A | R | A | R |||| C | A ||| R || R || R | U | U || R | R ||| R | R | C | U | C | C | C | U | C || R || C | R | A || R || R ||| R | R | A | C | R | U || U |
| East Fork Poplar River | 2 ||||| C ||||| C | C ||| R | P | A || R | A | R || R | C ||| C | C | R |||| C || A ||||| PE ||| C ||||||| R | C | U ||||
| Middle Fork Poplar River | 2 ||||| C ||||| C | C ||| R || A || P || R || R ||| P | C | P | R |||| C || A ||||| PE ||| C ||||||| R | C | U ||||
| Poplar River | 2 ||||| P ||||| C | C ||||| R | R | C || C || C | R ||| C | C | U |||| C || A || R ||| R ||| U |||| R ||| R | C | R ||||
| West Fork Poplar River | 2 ||||| C ||||| U | U ||||| U || A | A | A || R | R ||| A | C ||||| R || A || R ||| R ||| C |||| U ||| P | U | R ||||
| Redwater River - Reach #1 | 2 |||||||||| U | U ||||| R | R ||||||||||||||||||||||||||||||||||||||
| Redwater River - Reach #2 | 2 ||||| R ||||| U | C |||| R | R | R | U | A | U || U | U ||| A | U ||||| R || A || U ||| PE ||| C || C ||||||| U ||||
| **Little Missour River Subbasin** |||||||||||||||||||||||||||||||||||||||||||||||||||||||
| Beaver Creek (Wibaux Co.) | 2 ||||| C ||||| U | C | C ||| C ||| C | C | U | A | U || C || C | C | R || R || C || C || C | C | PE | R ||| C | C || U ||| R | U | C | C ||||
| Boxelder Creek | 2 ||||| U ||||| P | U || C || C ||| A | C || A ||| C || C | C | U |||| A || C || U || C ||||| U |||||| U ||||||
| Little Beaver Creek | 3 ||||| C ||||| R | U || R ||| A ||| A || C ||| R || A |||| R || C || A || C | C || U |||| R ||||| U || C | C ||||
| Little Missouri River | 2 ||||| U |||||| U || C || C ||| A | C || C ||| C || C | C | U |||| A || C || U || C || U || U |||||| U ||||||

# APPENDIX I

## DFWP'S PROPOSED WATER RESERVATION MANAGEMENT PLAN AND ADMINISTRATIVE PROCEDURES PROPOSED BY THE SHERIDAN COUNTY CONSERVATION DISTRICT

# DFWP MANAGEMENT PLAN (FROM DFWP'S WATER RESERVATION APPLICATION)

ARM 36.16.106(2) states, "A management plan shall accompany all reservation applications for instream uses (s) as defined in ARM 36.16-102(14), and shall include an explanation of how reserved instream flows will be protected from future depletions by later priority date water users.

The following addresses that requirement.

## MONITORING INSTREAM WATER RESERVATIONS

Implementation of a reservation monitoring/protection program will be an evolving process. A water reservation granted by the Board, by law, cannot affect any existing water users. In the Missouri River basin, the priority date of all reservations has been established by the Legislature as July 1, 1985. In the Little Missouri River basin, the established priority date is July 1, 1989. Only subsequent (junior) water use permit holders will be affected by DFWP's reservations. Existing rights are not affected and only the status quo of streamflow conditions at the time the reservations are granted is maintained. Because our requests would allow some new future depletions, the status quo is the "best" condition that can be maintained. If new depletions do occur, future streamflows could be less than existing flows during some time periods.

The basis for our protection program is what we call the "Reach Concept." Stream reaches for waters in this application extend from upstream to downstream boundaries as identified in the individual stream write-ups. A reach, as defined by DFWP, merely serves as a means to identify those junior water users who will be subject to the instream reservation, which is intended to be monitored at a site near the reach's downstream boundary. A reach does not represent a stream segment having the same flow regime and instream flow requirement throughout its length.

There is one potential problem with DFWP's reach concept. If all upstream junior users are keying to a flow level at the lower end of the reach, the potential exists for a single, large, new consumptive user in the headwaters to severely dewater an upper stream segment without materially impacting flow in the lower reach where the instream flow is monitored and protected. Whether or not this shortcoming poses a real threat to future streamflows is yet to be seen.

From a practical standpoint, the protection of water reservations is key to any instream flow program, and monitoring of those flows is the key to protection. It makes little difference whether a granted flow is for a short reach or a long reach of stream. A monitoring site which can be used to trigger the protective procedures (placing a "call" on the water) must be established. Placing a "call" only on junior users above a monitoring site will affect actual streamflow within the reach proportionally, depending on the location and the amount of their appropriations. It makes no difference whether there is more than one reach or what length the reach is; the junior users are the only ones affected by DFWP's reservations.

Once the reservations in the lower and Little Missouri basins are granted, main-stem river segments will initially be monitored using established USGS gauges. Tributaries having existing gauges will be similarly handled. We will also look at the necessity of installing new gauges. For tributary streams and reaches without gauges, we would initially monitor flows at the nearest downstream gauge. Junior users in tributary streams above the respective gauge could potentially be notified if the granted flows are not being met at that gauge. As the number of junior users on ungauged reaches increases and the total effects of those new diversions become more significant, our monitoring program will be expanded.

The reservations will not increase water availability; they will, at best, only preserve an existing flow condition. As previously mentioned, this existing condition begins on the date the reservations' priority is established. We affect water availability for only those users who are issued subsequent (junior) permits, whereas senior water users are unaffected. We protect streamflows at whatever level occurs after all senior users have exercised their rights and after junior users have further reduced flows to the granted amounts of the instream reservation. In those cases where senior users are already capable of depleting flows below the granted amounts of the instream reservations, little water will be available for junior users.

## PLACING A "CALL" ON THE WATER

DFWP is in the best position to determine the extent of a monitoring/enforcement program for granted instream reservations. We will proceed in a manner similar to what has evolved in the Yellowstone Basin and with our "Murphy Rights."

The first step is to monitor new applications for water use permits which will be junior to the reservations. DFWP notifies each applicant, either through a letter or the objection process, that an instream flow reservation exists in the supply source and that, at some future time, he/she may be asked to cease water use because of low stream flows. DNRC conditions all junior water use permits to water rights in existence at the time the permit is issued. In most cases where DFWP objects, the permit is also specifically conditioned to senior DFWP instream flow reservations. In some cases where granting the requested permit would significantly impact our reservations, we object and request the permit be denied.

If a drought or low flow year is eminent, DFWP obtains from DNRC a current listing of all water users who are junior to the reservations. An initial letter is sent to them in June I advising them of flow conditions and informing them that they might be subject to a "call" on their junior water. If flow conditions deteriorate and fall below the reservations, DFWP sends a second letter to notify junior users that they must cease their diversions until flows again rise above the reservations. A stream gauge is assigned to them so they can monitor flow levels, and they are given phone numbers of DFWP and the closest DNRC Water Rights Field office so they can readily obtain up-to-date flow information.

Shutting off junior users will not always increase flow levels in a drought year and flows may remain below the reservations for the entire irrigation season. DFWP realizes its reservations cannot always be met under drought conditions (as we experienced in 1988).

To date, when DFWP has called for its water, it has relied on voluntary compliance by junior users. A more efficient system must eventually be developed which will ensure junior user compliance. The use of water commissioners may be a means to accomplish this. Also, DNRC has authority to enforce compliance by junior permit holders, and we have relied on this process to obtain compliance by junior users who had not heeded our written call for the water.

Finally, DFWP is responsible for protecting reservations once they are granted. How, when, and where this is done depends on several factors:

1. Need. How many junior water users are there to protect against?

2. DFWP Funds Available. Funding levels may vary. Our ability to contract with USGS for gauging stations will depend upon the annual availability of these funds.

3. USGS Funds Available. Federal funding levels (USGS matching money) are often uncertain due to budget reduction efforts by the federal government. our ability to contract with USGS will also depend on its level of funding.

A broader base of funding at the state level would enable a stronger gauging network to be established in the long term and would provide benefits to all Montana water users.

## STREAM GAUGING COSTS

There are a number of ways to obtain stream gauging data, ranging from observations of a simple staff gauge to the more sophisticated satellite stations which make "real time" flow data available.

One of the requirements of any flow monitoring program used to protect instream water rights is to have flow data available when it is needed, usually on a daily basis. This is necessary so that junior water users can be kept informed of their water use possibilities. To meet these needs, DFWP has utilized staff gauges which are read daily by observers who then report the flow levels by telephone. Also, "real time" stations have been established by the USGS and National Weather Service at a number of gauging stations in Montana. DFWP has access to this information through the Helena office of the USGS. Whatever system is used, access to the data when needed is important. (There are many other existing USGS gauge stations in Montana which cannot be as readily accessed.)

Another consideration when establishing a monitoring program is the expense of obtaining the needed flow data. If new gauging stations have to be established or existing stations moved to a more desirable location, the type of stations needed and their associated costs must be considered.

The following is a discussion of the approximate costs of installation and operation of various types of stream gauging equipment. These include:

1. staff gauges or wire weight gauges;
2. continuous streamflow gauging station with a yearly published record; and
3. "real time" stations.

These costs are approximate (as of 1991) and may need revision at the time a gauging program is actually implemented.

Staff gauge/wire weight gauge - This is the lowest level and least expensive means of obtaining streamflow data. A staff gauge or wire weight gauge is installed at a suitable stream site. A number of streamflows are measured at the site at different flow levels to develop a rating curve of streamflow vs. stage (water level). Once a suitable rating curve is established for the site, an observer (usually a local inhabitant) reads the elevation of the water level on the staff gauge or from the wire weight gauge and reports the information by telephone on a daily basis to DFWP.

The cost of installation of a staff gauge is about $200 if done by DFWP. Operation cost is approximately $500 per year, depending upon the availability of observers and their distance from the gauge site. This type of installation is usually operated for only 2-3 months each year during the irrigation season. The USGS charges $800 to install a staff gauge and $6,800 for a full year of operation.

A wire-weight gauge costs approximately $1,500 to install by the USGS. Annual operation cost is the same as for a staff gauge.

Continuous Streamflow Station with Published Record - This level of gauging requires the installation of a continuous recording instrument within a permanent housing facility at the stream site. A staff gauge or wire weight gauge is also installed. A number of streamflow measurements are made at different levels of flow to establish a rating curve for the station and, again, a stage/discharge rating curve is established for the station. Once the rating curve is established, an observer can read the gauge height at the station and report the reading daily to DFWP. The gauge height can then be converted to actual streamflow from the rating curve. An advantage of this type of installation over a staff gauge or wire-weight gauge installation is the continuous recording of streamflow which then becomes a permanent record published annually by the USGS.

The cost of such an installation varies depending upon site characteristics. A typical installation without a cable costs approximately $12,500. The cost of a cable depends on the specific site but could be $15,000 or more. A typical gauge installation consists of recorders placed in a permanent building at the stream site. A manometer (pressure activated system) or other automatic measuring device is required to measure the level of streamflow, which is then recorded.

Stilling well installations are flow recorders installed in small shelters mounted over an 18-inch well. These installations are limited to sites on small streams, canals, etc. where freezing problems are minimal. A small stilling well installation using new equipment costs approximately $5,000 per year. If surplus equipment can be used, the installation would cost about $3,500.

"Real Time" Stations - This type of installation is basically the same as the typical continuous streamflow installation described above with the exception that either telephone or satellite telemetry equipment is also installed at the site. Telephone systems require access to a phone line. A LARK recording unit receives flow data from the site and makes it available to anyone who telephones the station. The stage of the stream is transmitted over the phone line to the caller who then converts the stage height to actual streamflow using the stage-discharge relationship for that site. The approximate installation cost of a LARK unit is $2,500 plus the cost of a phone line which varies site-by-site. Phone line costs can be substantial. Again, the LARK cost is in addition to the installation costs for the typical continuous flow station described above.

Another type of recording unit is an Electronic Data Logger with a telephone modem attached which can be accessed by telephone to obtain the stage of the stream. The data logger itself is part of the typical installation and is included in those costs. If a modem is desired, there is an additional cost of $800. Operation costs are the same ($6,800 per year) as for other installations.

Satellite installations or DC's (Data Collection Platforms) allow the USGS to obtain gauging data via satellite. Sophisticated data recording equipment stores flow information every 15 minutes and transmits the data via satellite to a central receiving station. The information is then accessible via computer by USGS offices in Montana. Satellite telemetry can be purchased for about $5,000 - $6,000. This is in addition to the costs of the typical gauging station installation cited above. The operation cost is $6,800 per year, plus an additional cost to service the satellite equipment. If 24-48 hour servicing is required, the additional cost may be as high as $2,500 per year. If weekly servicing is adequate, the additional charge is approximately $600 per year.

The 1991 USGS cost to operate all of the types of stations just described is $6,800 per year. This will increase to $7,100 in 1992. These are total costs. DFWP funds this program 50/50 through our cooperative agreement with the USGS. The costs to DFWP, therefore, are one-half the costs shown above. The USGS pays the other 50 percent. Installation costs are also shared equally under the same agreement.

# SHERIDAN COUNTY CONSERVATION DISTRICT ADMINISTRATION PROCEDURES (FROM THE SHERIDAN COUNTY CONSERVATION DISTRICT'S WATER RESERVATION APPLICATION)

## INTRODUCTION

This section provides a procedure by which the District will allocate and administer water use under its reserved water right. The District will accept and process all applications for reserved water use until such time as all District water has been put to beneficial use for full service agricultural irrigation and stockwater purposes. Each applicant receiving District and Board of Natural Resources and Conservation approval must use the reserved water in accordance with a Water Use Authorization approved by the District. The actual water right is retained by the District and is subject to periodic review by the Board.

The District reserves the right to change the Administrative Procedures if necessary to comply with the Order of the Board for Water Reservations on the Missouri River Drainage.

## DEFINITIONS

1. **APPLICANT** means the person or persons who apply to the District for permission to use a portion of the water reserved to the District.
2. **APPLICATION** means an application to the District for an Authorization to use reserved water.
3. **AUTHORIZATION** (or **RESERVED WATER USE AUTHORIZATION)** is an instrument by which the District allows an applicant to use a portion of its reserved water.
4. **BENEFICIAL USE** is the use of reserved water for the benefit of the applicant, other persons, or the public for full service agricultural purposes or stock use.
5. **BOARD** means the Board of Natural Resources and Conservation.
6. **DEPARTMENT** means the Department of Natural Resources and Conservation.
7. **DISTRICT** means the Sheridan County Conservation District.
8. **PERSON** means an individual, association, partnership, corporation, state agency, political subdivision, the United States or any agency thereof, or any other entity.
9. **POINT OF DIVERSION** means the location of the facility used to divert water from a source of water in order that it be put to beneficial use.
10. **PROJECT** means the maximum acreage that can be irrigated utilizing the output from one irrigation well.
11. **RESERVATION** means the reserved water right granted to the District by the Board pursuant to an Order by the Board of Natural Resources.
12. **RESERVED WATER** means the water which was granted as the reserved water right of the Sheridan County Conservation District by the Board.
13. **SENIOR RIGHTS** mean those water rights or water use permits for the beneficial use of water in existence prior to July 1, 1985.
14. **SUPERVISOR** means one of the members of the governing body of the District.
15. **WASTE** shall mean the unreasonable loss of water through the design or negligent operation of a water distribution facility or the application of water to anything but beneficial use.
16. **WATER USER** means a person who is issued an Authorization.

## CONSERVATION DISTRICT RIGHTS AND RESPONSIBILITIES

This District's rights and responsibilities include but are not limited to the following:

1. Accept applications for beneficial use of reserved water and process the applications in a timely manner.
2. Advise and/or assist applicants who may request assistance in completing their application.

3. Levy application fees and service charges upon the water user for administration of reserved water use.

4. Submit Reserved Water Use Authorizations to the Board of Natural Resources and Conservation for approval.

5. Issue Reserved Water Use Authorizations to successful applicants.

6. Allocate reserved water use in an impartial manner.

7. Administer the Authorization for beneficial use of its reserved water right.

8. Maintain an accurate public record of reserved water use.

9. Provide an annual report of reserved water use to the Board.

10. Coordinate and cooperate with any local, state, or federal agency as necessary to fulfill the purposes of the reservation.

11. Periodically review Reserved Water Use Authorizations issued by the District to ensure that all Authorization conditions are being met.

12. Seek administrative and technical assistance from the Department.

## ADMINISTRATIVE PROCEDURES

### PRIORITY SYSTEM

The District reserved water right priority date is July 1. 1985. The District shall maintain a separate priority system within its reservation to administer preference of reserved water use. This District priority system shall be based on the First-in-Time, First-in-Right Doctrine with each water use priority date being that day on which the District accepts a Notice of Intent to Use Reserved Water, unless otherwise governed by the Deficient. Speculative, or Indirect Application sections.

### APPLICATION PROCEDURE

Portions of the Sheridan County Conservation District Reservation will be allocated using two similar mechanisms—indirect applications (transfers of eligible Provisional Permits) and direct applications to the District.

The applicant may request the District's assistance in completing the application (see Application for Reserved Water Use, Form No. 102, in Appendix F). The District will provide such assistance within its budgeting and staffing limitations. The District may in turn request the Department to assist an applicant in completing an application.

It will be District policy to print a news article in the legal county newspaper stating the reserved water applications to be reviewed by the District at their next regularly scheduled meeting. A formal objection may be submitted on a form prescribed by the District.

### FORMS

Forms shall be available at the District Office. The following forms are hereby accepted and shall be used in the administration of reserved water use:

1. Form No. 101, Notice of Intent to Apply To Use Reserved Water.

2. Form No. 102, Application for Reserved Water Use.

3. Form No. 103. Reserved Water Use Authorization.

4. Form No. 104, Water User Annual Status Report.

5. Form No. 105, Application for Change in Water Use Authorization.

6. Form No. 106. Notice of Completion of Water Development.

7. Form No. 107, Objection to Application for Reserved Water Use.

8. Form No. 108, Application for Extension of Time.

### INDIRECT APPLICATION

All eligible Provisional Permits granted by the Department between July 1, 1985 and December 31, 1991 may be transferred. if the permittee desires, to the District Reserved Water Right. given that the project is included in the Water Reservation Application or with District approval. A Notice of Intent to

Use Reserved Water must be submitted within ninety (90) days of Notice by the District that such transfers will be accepted. If the permittee decides to transfer and the District approves the application, then the permit will be terminated and an Authorization will be executed, with a priority date of July 1. 1985. Those Provisional Permit holders receiving an Authorization through indirect application shall be given an internal priority date equal to the Provisional Permit priority date.

## DIRECT APPLICATION

Any person who is interested in using reserved water may submit a Notice of Intent to Use Reserved Water to the District. This will provide a priority status for the forthcoming application. An application requesting water for full-service irrigation or stock use shall be submitted to the District within one year after submitting the Notice of Intent with extensions as approved by the District not to exceed an additional ninety (90) days.

When a landowner files a Notice of Intent to Apply for Reserved Water, the place of use designated in the Notice will be evaluated by designated technical support for suitability for irrigation. The evaluation will include:

1. Soil Suitability Evaluation

   A detailed soil survey based on field review is recommended for each project. This evaluation can be requested by the landowner at the Soil Conservation Service office and will be performed by a qualified soils and/or irrigation specialist. Because of the time involved in completing a detailed survey, the landowner should request this survey one year prior to planned implementation of the irrigation project. A map and narrative prepared by a qualified technician should include the following:

   a. Texture and structure of the soil surface.
   b. Changes in soil profile from the surface down.
   c. Profile restrictions - Hardpans or calcareous layers, gravel, or groundwater should be noted as possible limitations in crop root development.
   d. An estimate of moisture-holding capacity per foot or depth and an estimate for water and pumping demands.

2. Water Availability Evaluation

   A review of project location in relation to aquifer boundaries will be performed by a designated technical representative. Recommendations for a test well drilling program will be included in this evaluation.

The above evaluations will be sent to both the Conservation District and the landowner. Once this information is received, the landowner completes the Application for Reserved Water Use. The applicant must supply all the information as outlined in the Application Content Section. (See Application for Reserved Water Use, Form No. 102, Appendix F.) If the applicant is successful, an Authorization will be submitted with the application documents (Detailed Development Plan) to the Board for concurrence.

## APPLICATION REVIEW PROCESS

Notice of Intent to Apply to Use Reserved Water. Notice of Intent to Use Reserved Water shall be made on District Form No. 101. Information supplied shall include but is not limited to: applicant's name, address, and phone number; project location; and type of irrigation system to be used. The District will review the Notice and evaluate the place of use for soil suitability and water availability. The District will then issue the applicant a formal approval or denial to proceed with the Application for Reserved Water Use within sixty (60) days of Notice receipt.

Applications for Reserved Water Use shall be made on District Form No. 102. Information supplied shall include but is not limited to: applicant's address, and phone number; source of water supply; test hole drilling logs; test well installation information; pump test results; water quality analyses; soils evaluation; rate of diversion; period of use; total volume of water applied for; project location; point of diversion; preliminary engineering plans; and type of irrigation system to be used. A legible map shall accompany the application. The map shall include: township, range, and section numbers and corners; point of diversion; location of project; outline of area to be irrigated; name, address, and signature of applicant; and person preparing map (if not applicant). An ASCS aerial photo or a USGS topographic map is sufficient.

The application also shall include a soils map with appropriate interpretations (from 'Notice of Intent' evaluation); a description of water measuring devices; economic analysis as requested by the applicant; and a construction schedule.

Where the application involves any variance from the reservation as granted by the Board to the District, the applicant shall specify in detail as to where there is a variance. The applicant shall indicate why such variance should be approved by the district and made a part of the Authorization.

## DEFICIENT APPLICATION

No application shall be processed or acted upon by the District until it is complete and in compliance with the reservation and these rules. If an application is deemed by the District to be deficient, it shall be returned to the applicant for correction or completion, together with the reasons for returning it. An application will not lose priority of filing because of defects or omissions if the application is corrected or completed and refiled with the District within thirty (30) days after it is returned to the applicant. If an application is not corrected or completed within thirty (30) days, the priority date of the application within the reservation shall be the date of acceptance of the completed application. Only a complete application shall receive a priority date. (See also Priority System, page 171.)

## SPECULATIVE APPLICATION

The District may cease action upon an application and return it any time to the applicant when it finds that the application is not in good faith or does not show a bona fide intent to appropriate water for beneficial use. An application returned for either of these reasons shall be accompanied by a statement of the reasons for which it was returned. There shall be no right to a priority date based upon the filing of the application. (See also Application Modification or Denial Section. Page 179.)

## GUIDELINES FOR APPLICATION REVIEW BY CONSERVATION DISTRICT

Upon review of the application, which shall be not later than ninety (90) days after accepting a completed application, the District may, based on review criteria, approve, modify, or deny the proposed plan or portion thereof before submitting such plans to the Board for its approval.

## VARIANCE PROCEDURE

If an application proposes a point of diversion, place of use, or use that varies from the Reservation as granted, the District shall submit DNRC Form No. 606, Application for Change of Appropriation Water Right, to the Department. After the District has been informed by the Department of the final variance status, the District shall approve, modify, deny, or condition an application in whole or in part within ninety (90) days after receipt of the decision. (See also Application Modification or Denial Section. Page 179.)

## APPLICATION REVIEW CRITERIA

The District may issue an Authorization if:

1. Reserved water is available at the intended point of diversion.
2. The proposed use will not adversely affect senior water rights.
3. The proposed project/system is adequate.
4. The proposed use is compatible with the district's Annual Work Plan and local and regional planning efforts have been compared.
5. The proposed use meets the objectives of the reservation.
6. The applicant agrees to obtain all applicable local, state, or federal permits, authorizations, approvals, or licenses.
7. The proposed use of water is a beneficial use.
8. The application demonstrates adequate and reasonable soil and water conservation measures.

The District may require the applicant to provide information to establish the above criteria.

## APPLICATION MODIFICATION OR DENIAL

An application may not be approved in a modified form by the district, nor denied, unless the applicant is first granted an opportunity to file a written statement as to why the application should not be modified or denied. If the District is of the opinion that the application should be approved in a modified form or that the application should be denied, the District shall prepare a statement of its opinion and serve it by certified mail (return receipt requested) upon the applicant, together with a notice that the applicant may file a written statement and meet with the district supervisors by filing a request within thirty (30) days after the notice is mailed. The notice shall state that the application will be modified in a specified manner, or denied, unless the applicant wishes to present a written statement of why the application should not be modified or denied at the District's next regularly scheduled meeting or other mutually agreed upon time.

### RESTRICTIONS

Construction/Start-Up Limitations. The applicant may not commence construction of any portion of their project plan until the applicant has a Reserved Water Use Authorization signed by the district and approved by the Board.

### FEES

Application and/or administrative fees may be established by the District. Fees, if any, will be included in the District's Annual Work Plan. Failure to pay the fee shall be cause of revocation of an Authorization.

### BOARD APPROVAL

After the District has approved the application and variance, if applicable, the final Authorization and the application with attached documents (Detailed Development Plan) will be sent to the Board for approval. The process will be completed within six (6) months after the Authorization and the Detailed Development Plan have been received by the Board.

### RECORD KEEPING

A six-part folder may be used in filing Reserved Water Use Authorizations. The folder may be set up as follows:

| | |
|---|---|
| Section I | Correspondence, Initial Application |
| Section II | Authorization Documents and Transfers |
| Section Ill | Annual Status Reports From Water Users |
| Section IV | General Development Layout |
| Section V | Resource Data: Soils. Geology, etc. |
| Section VI | Engineering Drawings and Data |

These folders may be filed alphabetically for easy access. A file should be maintained in the following locations:

One (1) Water User(s)
One (1) Conservation District Office (Original)
One (1) Water Development Bureau Office, Helena

## AQUIFER REASSESSMENT

Aquifer reassessment should be performed once every two years, or every year if new applications for water use are numerous. This reassessment will be performed by Sheridan County Conservation District staff with the assistance of designated technical support.

Data collection for the re-assessment should include:

- Collection of flow period data from irrigators. (Information from Form 104 - Water User Annual Status Report)
- Quantification of total withdrawals.
- Compilation and computer entry of water level data.
- Preparation of hydrographs.

Aquifer simulation (computer modelling) should be performed periodically using the "Management level" digital model of the Westby-Dagmar aquifer prepared by Donovan (1986) for the Northeast Montana Groundwater Study. The modelling will allow for continued refinement of aquifer recharge, yield, and storage estimates, as well as to assist in determining effects of irrigation on area lakes.

This information should be instrumental in determining or predicting when aquifer capacity for development is being approached, and for determining what areas of the aquifer would be most sensitive to new development. "Red flag" conditions, such as unacceptable levels of drawdown in lakes or reductions in aquifer yield estimates, could be determined from the computer simulations.

The model will require interpretive refinement as more precise calibration becomes possible with new data. This work will likely have to be performed by or under the supervision of a technical specialist, possibly the DNRC Water Management Bureau.

## ADMINISTRATIVE RULES

Reserved Water Use Authorization - General Terms

An Authorization will be issued for each applicant's project which utilizes the District Reservation, and will be subject to any senior water rights. An Authorization is shown on Form 103 in the Appendix.

The priority system within the District's Reservation will be based on a first-in-time, first-in-right basis. The District may order verbally or in writing, a temporary suspension to water use under an Authorization if the District determines that senior reserved water users will be harmed due to water shortages. Failure to stop reserved water use within twenty-four (24) hours of notice is cause for revocation of the Authorization.

The District may not issue an Authorization for more water than can be beneficially used without waste for the purpose stated in the application. The District may require modification of plans and specifications for the proposed project or related diversion or construction. The District may issue an Authorization subject to terms, conditions, restrictions, and limitations it considers necessary to protect the District's reservation. The Authorization shall be issued subject to existing rights and any final determination of existing rights as provided by law.

The District may limit the time for commencement of the appropriation works, completion of construction. and actual application of the water to the proposed beneficial use. In fixing those time limits, the district shall consider the cost and magnitude of the project, the engineering and physical features to be encountered, and, on projects designed for gradual development and gradual increased use of water, the time reasonably necessary for that gradual development and increased use. The District may in its discretion reasonably extend time limits. (See Priority System. Page 171.)

Reserved Water Use and Completion of Projects. The applicant must agree to use the district's reserved water according to all applicable local, state, and federal laws. The water use structure(s) must be built within one (1) year after date of Authorization. The District, upon written request and for good cause, may extend such time period. A Notice of Completion of Water Development, Form 106, shall be filed with the District within sixty (60) days after completing the project. Failure to file Form 106 within the specified time is cause for revocation of the Authorization.

Revocation of Water Use Authorization. The District may revoke an Authorization as provided under these rules. Additionally, if the work of an appropriation is not commenced, prosecuted, or completed within the time stated in the Authorization or an extension thereof, or if the water is not being applied to the beneficial use contemplated in the Authorization, or if the Authorization or Board order creating the reservation is otherwise not being followed, the District may revoke the Authorization. Specific cases include but are not limited to the abandonment of the reserved water use or an irrigation system by the water user, violation of Authorization provisions, or the waste or misuse of allocated water. The Department shall be notified of any Authorization revocations.

Violation of Water Use Authorization. The applicant is responsible for using water in accordance with an Authorization issued by the District. Violations of the Authorization are cause for the District to revoke the Authorization. The water user shall be given written notice of the violation and shall be given a reasonable period to correct the violation. If the Authorization is revoked, the water will be made available for subsequent allocation.

Abandonment. Abandonment of the reserved water use or an irrigation system by a water user will cause that Authorization to be revoked. The District will contact the water user before revoking an Authorization to determine the cause and intent of abandonment.

The District will consider a reserved water use or an irrigation system to be abandoned if the reserved water use or respective system has not been used for a period of three (3) consecutive years, provided water for diversion was available during that time. The District may grant an extension if circumstances indicate that the water user had no intentions of abandonment.

Waste of Reserved Water. The water user may use water by any method acceptable in the area. Such use shall be in the most efficient manner possible for the particular method. Any misuse or waste of water shall result in revocation of the Authorization by the District.

Sever and Sell. A water user shall not sever and sell all or any portion of the District's reserved water allocated to him under his water use authorization.

Transfer of Allocations. The right to use water under an Authorization shall pass with conveyance of the land, or transfer by operation of law. All transfers of Authorizations shall be without loss of priority date. Transferees must file an Application for Change in Water Use Authorization with the District prior to such transfer. Failure to notify the District is cause for revocation of the Authorization. An Application for Change in Water Use Authorization, Form 105, is shown in the Appendix F.

Authorization Revocation Meetings. Before an Authorization is revoked, the District shall invite the user to the next regularly scheduled District meeting or mutually agreed upon time. At such meeting the water user may present information to the district to show that there is no violation, abandonment, waste or misuse of water, or other grounds for revocation of the Authorization. The District may revoke or modify the authorization upon determining that grounds exist for revocation. The District shall either revoke the Authorization or, if circumstances warrant, modify the Authorization to prevent a further violation of the Authorization.

## RESPONSIBILITIES OF THE WATER USER

Use of Water. The water user shall use the reserved water of the District for the purpose(s) as outlined in the Authorization. If there is a change in the point of diversion, place of use, method of application, or point of discharge. an Application for Change in Reserved Water Use Authorization, Form 105, must be filed with the District by the water user prior to change. If a change involves a variance, the Variance Procedure will be initiated. (See Variance Procedure, Page 178.)

Provisions for Flow Measurement. The water user shall be responsible for measuring and reporting flow rates and volume used depending on the type of development. The flow measurement can be based on commonly acceptable methods as determined by the District and indicated in the Reserved Water Use Authorization.

System Operation. The water user shall maintain the irrigation system in an efficient, safe, and operable condition. Said system shall be installed, operated, and maintained according to any applicable federal, state, and local laws. Damages due to natural causes shall be repaired as soon as practicable. Systems shall be operated so as to minimize such damages.

Water Management. The water user, as well as the District, is subject to the requirements of the Board, the rules adopted by the Board governing water reservations, and the laws of the State of Montana. The water user shall be required to adhere to any water management operations that may be implemented in the future by the State of Montana or the District. The irrigation system shall be operated in such a manner as to incorporate current standard conservation practices. Such practices include, but are not limited to, the minimization of soil loss, conservation of water, and maintenance of reasonably low soil salt levels. Waste of water or failure to adhere to accepted conservation practices is grounds for revocation of the authorization.

Reduction Enforcement. The District may order a temporary reduction in water use under a water use authorization if the District determines that senior water users are being harmed due to water shortages. Failure to reduce reserved water use within twenty-four (24) hours of notice to water user or his agent is grounds for revocation of an authorization. Any verbal order shall be followed up by written notice, served by certified mail (return receipt requested), setting forth the reasons for the terms of the order.

Easement and Right of Way. It is the obligation of the water user to acquire all easements and right-of-ways necessary to convey water to areas of use.

Entry on Land. Any employee or agent of the District authorized by the District may enter upon land to make inspections the District considers necessary on the proposed works, source of water, location of proposed use, construction of works and other inspections to ascertain whether or not persons are complying with their Authorization. Failure to allow an authorized employee or agent of the District upon the land for the above purposes is cause for revocation of the Authorization.

Annual Status Report. The water user shall submit an annual report to the District by November 1 of each year setting forth the development or use accomplished under the application or Authorization during the preceding year. This requirement shall remain in effect until the district is no longer required to submit such information to the Board. Failure of the water user to submit this report for each year shall be grounds to revoke the Authorization. (See also Authorization Revocation Meeting Section, Page 186.)

## DISTRICT RESPONSIBILITIES

Allocations of Water. Sufficient water will be granted to satisfy the quantity required by the design of the system which normally is 3.13 A/ft per acre for full-service irrigation. These allocations will be within the actual amount on hand for dispersal at the time of the issuance of an Authorization.

Use of Reserved Water. It is the intent of the District to use reserved water for full-service irrigation and stock use.

Revisions. The Sheridan County Conservation District reserves the right to add to, delete from, or modify this plan upon serving notice to and receiving approval from the Board of Natural Resources and Conservation. Any changes will apply to only those Authorizations issued after the effective date of such change.

Legal Assistance. The District may request the Attorney General and the County Attorney to perform legal services and conduct legal proceedings necessary to carry out the purpose of this plan and the basis of the Authorizations. The district may also employ legal counsel to enforce Authorizations and to conduct proceedings under these rules.

Technical Assistance. The District, within financial and personnel limitation, will assist water users in completing Annual Reports, flow measurements, and determining operating efficiencies of systems using reserved water.

## GOVERNING RULES OF THE BOARD OF NATURAL RESOURCES AND CONSERVATION

The District and the Water User are subject to the requirements of the Board of Natural Resources and Conservation, the rules adopted governing water reservations, and the laws of the State of Montana.

## OWN OR CONTROL OF RESERVED WATER

It is specifically understood that the District has exclusive control over the water reservation granted by the Board and that the water user receives no right, title, ownership, control, or interest in the water reservation. The ownership by the Water User of the conveyance, measuring or delivery devices, or equipment associated with the proposed development shall not be construed to limit the District's ownership and control of the water reservation. This, however, does not limit the responsibilities of the District to the Water User under the specific Authorization issued.

## LIABILITY-WAIVERS

The District, the supervisors, and the water user are subject to the requirements of the Board, the rules governing reservations, and the laws of the State of Montana. The District and the supervisors shall not be responsible to the water user for any change, including modification or revocation of the reservation by the Board, the State of Montana, or the courts. The reservation and rights of the user may be modified or revoked by the Board, the State of Montana, or the courts. The reservation and rights of the user may be modified or revoked by the Board if it finds that the objectives of the reservation are not being met. Except where it can be shown that such modification or revocation by the Board is wholly due to willful negligence on the part of the District or the supervisors, the water user shall expressly agree not to hold the District or the supervisors liable for any losses sustained by the user or third parties because of such modification.

The water user shall indemnify and the hold harmless the District and the supervisors against and from any and all claims, demands, or actions resulting from damages to property or injury to persons or other damages to third persons or entities arising out of, or resulting from the performance of the authorization or the results of the authorization. The water user shall assume all liability connected with the use of reserved water under a Reserved Water Use Authorization.

Neither the District nor the supervisors are responsible for any losses incurred by a user from loss of water due to such circumstances as a drought, a final determination of senior water rights in the source of supply, activities of an officer of a court such as, but not limited to, a water commissioner, or other circumstances outside the immediate control of the supervisors. The supervisors or the District shall not be held liable for any losses sustained as a result of the modification or revocation of any authorization or portion thereof pursuant to these rules. The water user agrees to sustain any and all loss occasioned thereby.

It is specifically understood that the District has exclusive control over the water reservation granted by the Board and that the water user receives no right, title, ownership, control, or interest in the water reservation. The water user may own conveyance, measuring, or delivery devices or equipment associated with the exercise of the water right under the reservation. Such ownership shall not be construed to limit the District's ownership and control of the water reservation granted by the Board.

# APPENDIX J

## MONTHLY FLOWS REMAINING AFTER REQUESTED INSTREAM FLOWS ARE SUBTRACTED

## Table J-1. Monthly flows remaining (cfs) during wet (20%), average (50%), and dry (80%) years after DFWP instream reservation requests are subtracted *

### MILK RIVER SUBBASIN

Beaver Creek above Bower Lake near Havre

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 5 | 5 | 4 | 1 | 6 | 26 | 32 | 119 | 67 | 24 | 6 | 3 |
| 50th % | 0 | 0 | 0 | 0 | 1 | 11 | 16 | 16 | 31 | 4 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 11 | 12 | 0 | 0 | 0 |

Little Boxelder Creek at mouth at Clear Creek road, near Havre

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 2 | 2 | 1 | 0 | 5 | 17 | 16 | 17 | 14 | 6 | 1 | 0 |
| 50th % | 0 | 0 | 0 | 0 | 0 | 5 | 4 | 2 | 2 | 0 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |

Clear Creek at Clear Creek Road crossing, near Lohman

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 0 | 0 | 0 | 0 | 1 | 29 | 18 | 27 | 22 | 5 | 0 | 0 |
| 50th % | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 1 | 1 | 0 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Battle Creek near international boundary

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 0.3 | 0.3 | 1.9 | 0.5 | 32.5 | 103.7 (0) | 70.8 (0) | 87.2 | 62.3 | 22.8 | 0 | 0 |
| 50th % | 0 | 0 | 0 | 0 | 3.2 | 32.4 (0) | 12.6 (0) | 9.7 | 12 | 0 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 10.0 (0) | 1.6 (0) | 0 | 0 | 0 | 0 | 0 |

Battle Creek at mouth, near Chinook

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 11 | 5 | 5 | 0 | 12 | 91 (0) | 80 (0) | 111 | 42 | 21 | 3 | 2 |
| 50th % | 0 | 0 | 0 | 0 | 0 | 13 (0) | 26 (0) | 29 | 16 | 7 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Peoples Creek at Barney Olsen Road, near Dodson

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 1 | 1 | 1 | 0 | 5 | 17 | 17 | 16 | 19 | 7 | 1 | 0 |
| 50th % | 0 | 0 | 0 | 0 | 0 | 6 | 6 | 3 | 5 | 1 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 |

Beaver Creek at Ft. Belknap Indian Reservation, near Zortman

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 0.3 | 0.8 | 0.3 | 0.1 | 0.1 | 0.3 | 0.8 | 1.8 | 2.8 | 0.8 | 0.8 | 0.3 |
| 50th % | 0.2 | 0.3 | 0.1 | 0 | 0 | 0.3 | 0.3 | 0.3 | 0.8 | 0.3 | 0.3 | 0.2 |
| 80th % | 0.1 | 0.1 | 0 | 0 | 0 | 0.1 | 0.1 | 0 | 0 | 0.1 | 0 | 0 |

Beaver Creek at mouth, near Saco

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 27 | 7 | 6 | 1 | 51 | 332 (182) | 214 | 632 | 196 | 118 | 18 | 10 |
| 50th % | 0 | 0 | 0 | 0 | 2 | 73 (0) | 14 (0) | 80 | 24 | 16 | 3 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 14 (0) | 0 | 7 | 0 | 0 | 0 | 0 |

Frenchman Creek at mouth, near Saco

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 7 | 5 | 4 | 1 | 4 | 179 (0) | 681 (483) | 172 | 80 | 29 | 6 | 2 |
| 50th % | 0 | 0 | 0 | 0 | 0 | 67 (0) | 212 (0) | 49 | 14 | 6 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 9 (0) | 42 (0) | 10 | 0 | 0 | 0 | 0 |

Rock Creek at mouth, near Saco

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 5 | 2 | 3 | 1 | 9 | 736 (345) | 1122 | 156 | 107 | 51 | 2 | 0 |
| 50th % | 0 | 0 | 1 | 0 | 0 | 149 (0) | 231 (0) | 38 | 26 | 5 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 16 (0) | 51 (0) | 12 | 6 | 0 | 0 | 0 |

### LOWER MISSOURI SUBBASIN

Missouri River below Fort Peck

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 8300 | 6100 | 4300 | 5600 | 6800 | 5100 | 2500 | 1932 | 1600 | 5400 | 10300 | 10500 |
| 50th % | 3300 | 2010 | 2320 | 2860 | 1240 | 1620 | 0 | 0 | 0 | 2300 | 4300 | 3600 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Missouri River near Wolf Point

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 9100 | 6100 | 4300 | 5600 | 7000 | 6100 | 8400 | 3752 | 1600 | 6300 | 10400 | 11400 |
| 50th % | 3200 | 2010 | 2020 | 2780 | 2030 | 1980 | 2180 | 0 | 0 | 2920 | 5000 | 4500 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 740 | 0 |

Redwater River above confluence of EF Redwater, near Vida

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 3 | 1 | 2 | 0 | 65 (0) | 219 (101) | 59 | 31 | 98 | 49 | 3 | 1 |
| 50th % | 0 | 0 | 1 | 0 | 1 (0) | 75 (0) | 21 (0) | 8 | 10 | 3 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 12 (0) | 6 (0) | 2 | 1 | 0 | 0 | 0 |

Redwater River near Vida

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 3 | 1 | 2 | 0 | 81 (0) | 272 (140) | 73 | 39 | 121 | 60 | 3 | 0 |
| 50th % | 0 | 0 | 1 | 0 | 2 (0) | 93 (0) | 26 (0) | 10 | 12 | 3 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 15 (0) | 8 (0) | 2 | 1 | 0 | 0 | 0 |

West Fork Poplar River at Fort Peck Reservation boundary, near Richland

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 4 | 4 | 3 | 1 | 3 | 86 | 97 (0) | 13 (0) | 21 | 8 | 2 | 1 |
| 50th % | 2 | 2 | 1 | 0 | 0 | 37 | 9 (0) | 0 | 10 | 2 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 4 | 0 | 0 | 0 |

Poplar River above confluence of East Fork Poplar River, near Scobey

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 4 | 4 | 3 | 1 | 3 | 206 | 323 (210) | 27 | 29 | 8 | 1 | 1 |
| 50th % | 2 | 2 | 1 | 0 | 0 | 61 | 30 (0) | 0 | 11 | 2 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 3 | 0 | 0 | 0 |

East Fork Poplar River at mouth, near Scobey

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 0 | 0 | 1 | 1 | 2 (0) | 71 (19) | 148 | 27 | 22 | 2 | 1 | 0 |
| 50th % | 0 | 0 | 1 | 1 | 1 (0) | 2 (0) | 0 | 5 | 1 | 0 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 1 (0) | 0 | 0 | 0 | 0 | 0 | 0 |

Poplar River at Fort Peck reservation boundary near Scobey

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 10 | 11 | 7 | 1 | 7 | 290 | 373 (238) | 49 | 62 | 20 | 3 | 2 |
| 50th % | 5 | 5 | 1 | 0 | 0 | 114 | 49 (0) | 2 (0) | 28 | 5 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 31 | 0 | 0 | 9 | 0 | 0 | 0 |

Missouri River near Culbertson

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 9500 | 5900 | 4500 | 5700 | 7200 | 7700 | 9900 | 4652 | 2300 | 6400 | 10100 | 11200 |
| 50th % | 3400 | 2020 | 1740 | 2030 | 2220 | 3400 | 3600 | 0 | 0 | 2920 | 4600 | 4600 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 0 | 430 | 0 | 0 | 0 | 590 | 100 |

## LITTLE MISSOURI SUBBASIN

Little Missouri River at Camp Crook, S.D.

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 10 | 0 | 2 | 1 | 34 | 608 (145) | 524 | 631 | 782 | 111 | 63 | 45 |
| 50th % | 0 | 0 | 0 | 0 | 1 | 187 (0) | 64 (0) | 63 | 222 | 38 | 8 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 33 (0) | 18 (0) | 9 | 14 | 6 | 0 | 0 |

Boxelder Creek at Webster

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 5 | 1 | 2 | 2 | 44 | 394 (119) | 278 | 248 | 256 | 65 | 30 | 20 |
| 50th % | 0 | 0 | 0 | 0 | 1 | 91 (0) | 51 (0) | 41 | 116 | 25 | 3 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 17 (0) | 10 (0) | 8 | 18 | 0 | 0 | 0 |

Little Beaver Creek near Marmarth, N.D.

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 3 | 1 | 0 | 1 | 43 | 263 (0) | 130 (129) | 46 | 135 | 34 | 6 | 11 |
| 50th % | 0 | 0 | 0 | 0 | 0 | 49 (0) | 25 (0) | 13 | 50 | 12 | 1 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 11 (0) | 6 (0) | 3 | 12 | 1 | 0 | 0 |

Beaver Creek at Wibaux

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 1.39 | 1.17 | 0.3 | 0.25 | 26.88 | 271.9 (148) | 151.2 | 10.8 | 33.6 | 12.7 | 2 | 0.5 |
| 50th % | 0 | 0.36 | 0 | 0 | 0.5 | 35.4 (0) | 13.3 (0) | 4.5 | 5.3 | 2.2 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 3.7 (0) | 3.5 (0) | 0.6 | 0.4 | 0 | 0 | 0 |

Beaver Creek near Trotters, N.D.

| MONTH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20th % | 1.3 | 1.3 | 1 | 1 | 62 | 428 (303) | 139.3 | 23.3 | 54.3 | 24.3 | 2.3 | 1.3 |
| 50th % | 0 | 0 | 0 | 0 | 4 | 70 (0) | 22.3 (0) | 7.3 | 9.3 | 4.3 | 0 | 0 |
| 80th % | 0 | 0 | 0 | 0 | 0 | 13 (0) | 6.3 (0) | 0.3 | 2.3 | 0 | 0 | 0 |

* Numbers in parentheses are an estimate of monthly flows that would remain after DFWP requested channel maintenance flows are subtracted.

Sources: DFWP 1991 and DNRC 1991

# APPENDIX K

## POPULATION AND WATER USE INFORMATION FOR LOWER MISSOURI RIVER BASIN MUNICIPALITIES

## Lower Missouri Municipal Existing Physical Water Use, Reservation Request, and Future NPA Population Based Physical Water Need

| Applicant | Existing Applicant SERVICE AREA Population | Existing Average Use Rate (g/c/d) | Existing Total Use (af/yr) | Applicant SERVICE AREA * Reservation Request (af/yr) | Future Year 2035 NPA Projected SERVICE AREA Population | Applicant Projected Average Use Rate (g/c/d) | Total Projected Service area Need (af/yr) | NPA future Increase in Physical Water Need (af/yr) | Notes on amount needed |
|---|---|---|---|---|---|---|---|---|---|
| Chinook | 1,765 | 184 | 364 | 800 | 1,870 | 200 | 420 | 55 | has 600 af BOR contract |
| Circle | 819 | 137 | 126 | 78 | 717 | 150 | 121 | 0 | adequate supply |
| Culbertson | 1,109 | 189 | 235 | 207 * | 834 | 225 | 211 | 0 | adequate city supply, also requesting additional 161 af for replacement supply to Roosevelt Cty. Rural Water Users Dist. |
| Ekalaka | 534 | 145 | 87 | 20 | 406 | 150 | 68 | 0 | adequate supply |
| Fort Peck | 271 | 542 | 165 | 100 | 270 | 500 | 151 | 0 | adequate supply; has highly *elevated unmetered use level |
| (alternative) | | | | | 442 | 500 | 248 | 83 | informational letter proposes service to outlying rural cabins |
| Harlem | 1,098 | 150 | 185 | 565 | 1,094 | 200 | 245 | 61 | has 500 af BOR contract, has *elevated unmetered use |
| Havre | 10,855 | 144 | 1,754 | 1,688 * | 11,717 | 150 | 1,972 | 218 | has 2,800 af BOR contract, also requests additional 337 af for replacement supply to existing north Havre sites (2,000 pop.) |
| Hill Cty WD | 3,500 | 96 | 377 | 652 | 3,700 | 113 | 467 | 90 | has 600 af BOR contract |
| Malta | 2,500 | 360 | 1,010 | 137 | 2,545 | 350 | 999 | 0 | adequate supply; has *elevated unmetered use levels |
| (alternative) | | | | | 2,636 | 350 | 1,035 | 25 | higher population boosts demand, has *elevated unmetered use |
| Plentywood | 2,410 | 220 | 595 | 235 | 1,668 | 250 | 468 | 0 | adaquate supply |
| Poplar | 3,295 | 116 | 429 | 448 | 2,821 | 150 | 475 | 46 | water demand growth |
| Scobey | 1,300 | 215 | 314 | 168 | 800 | 250 | 224 | 0 | adequate supply |
| Wibaux | 628 | 94 | 66 | 71 | 600 | 150 | 101 | 35 | water demand growth |
| Wolf Point | 4,080 | 172 | 787 | 504 | 3,973 | 200 | 892 | 104 | water demand growth |
| totals | 34,164 | 197 | 6,493 | 5,673 * | 33,015 | 217 | 6,814 | 609 | municipal needs if BOR contract water supply NOT increased (ignors 498 af of replacement water service requests) |
| | | | | | | | | 185 | actual water demand growth for population & per capita increases |

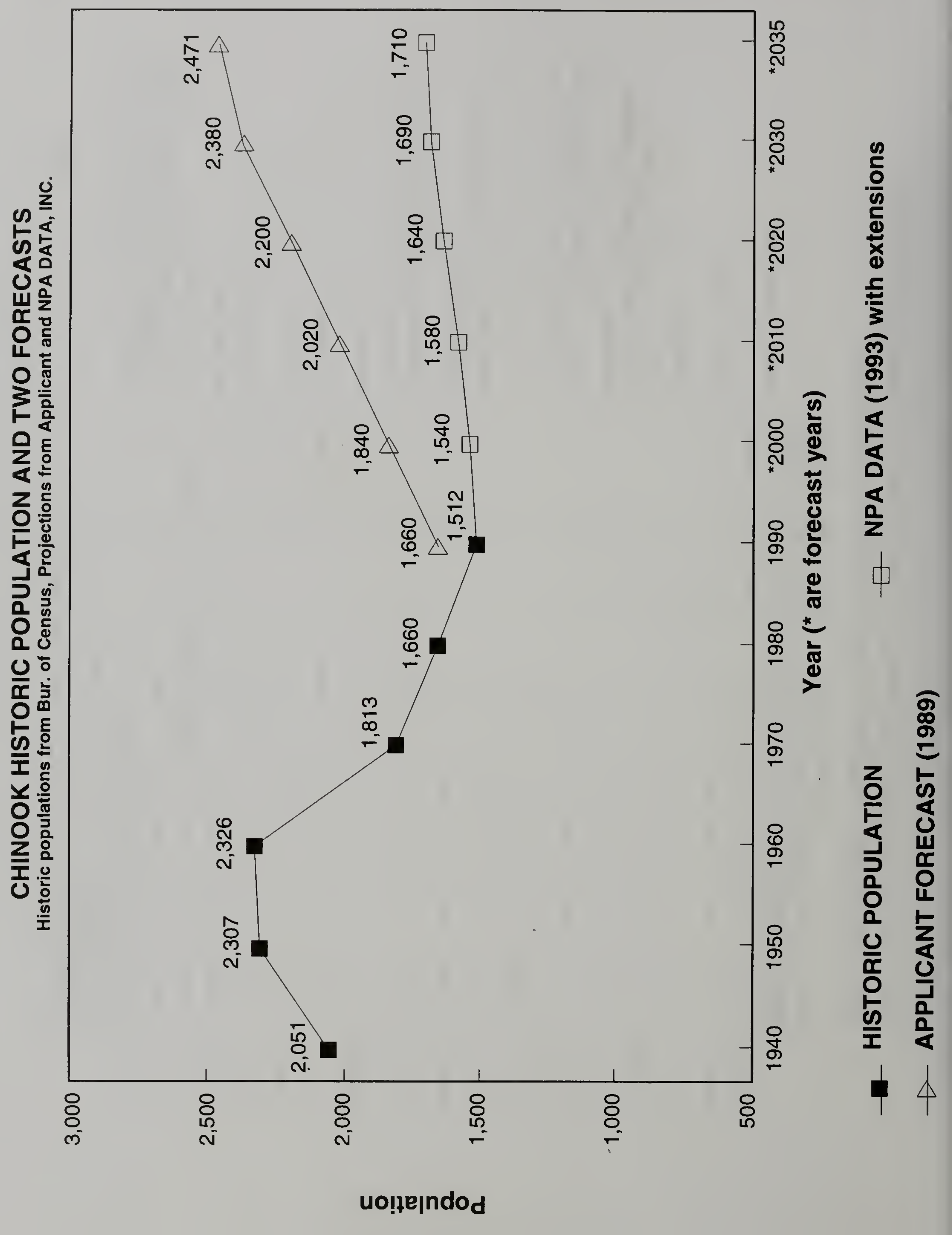
footnotes: *SERVICE AREA does NOT include replacement water service requests of 161 af (Roosevelt County WUD) and 337 af (north Havre)

SERVICE AREA includes persons recieving water service OUTSIDE the city limits.

g/c/d is gallons per capita per day

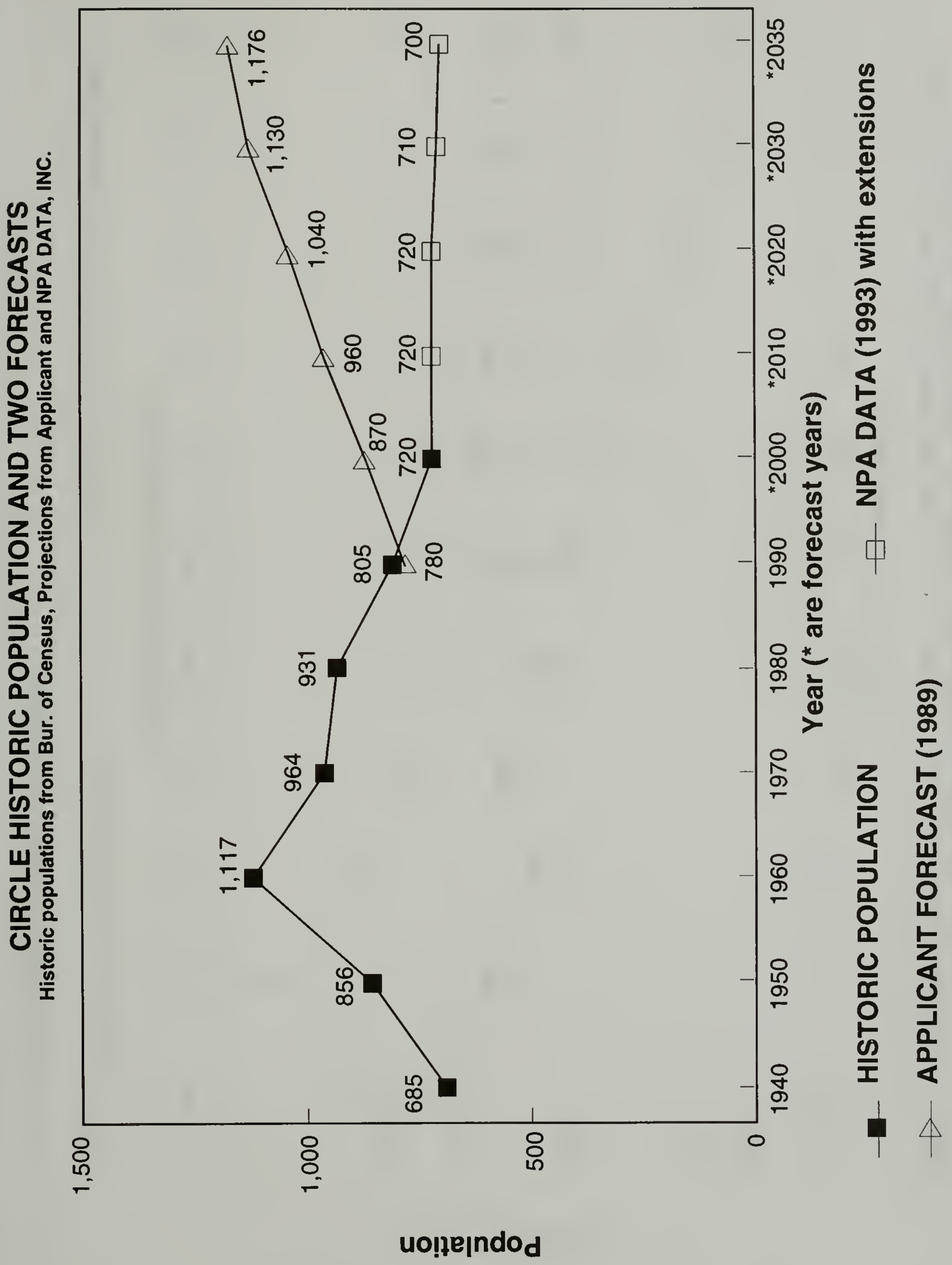
af/yr is acre feet of water per year

elevated unmetered water demands result in approximately 30 percent overuse due to unmetered water demand use



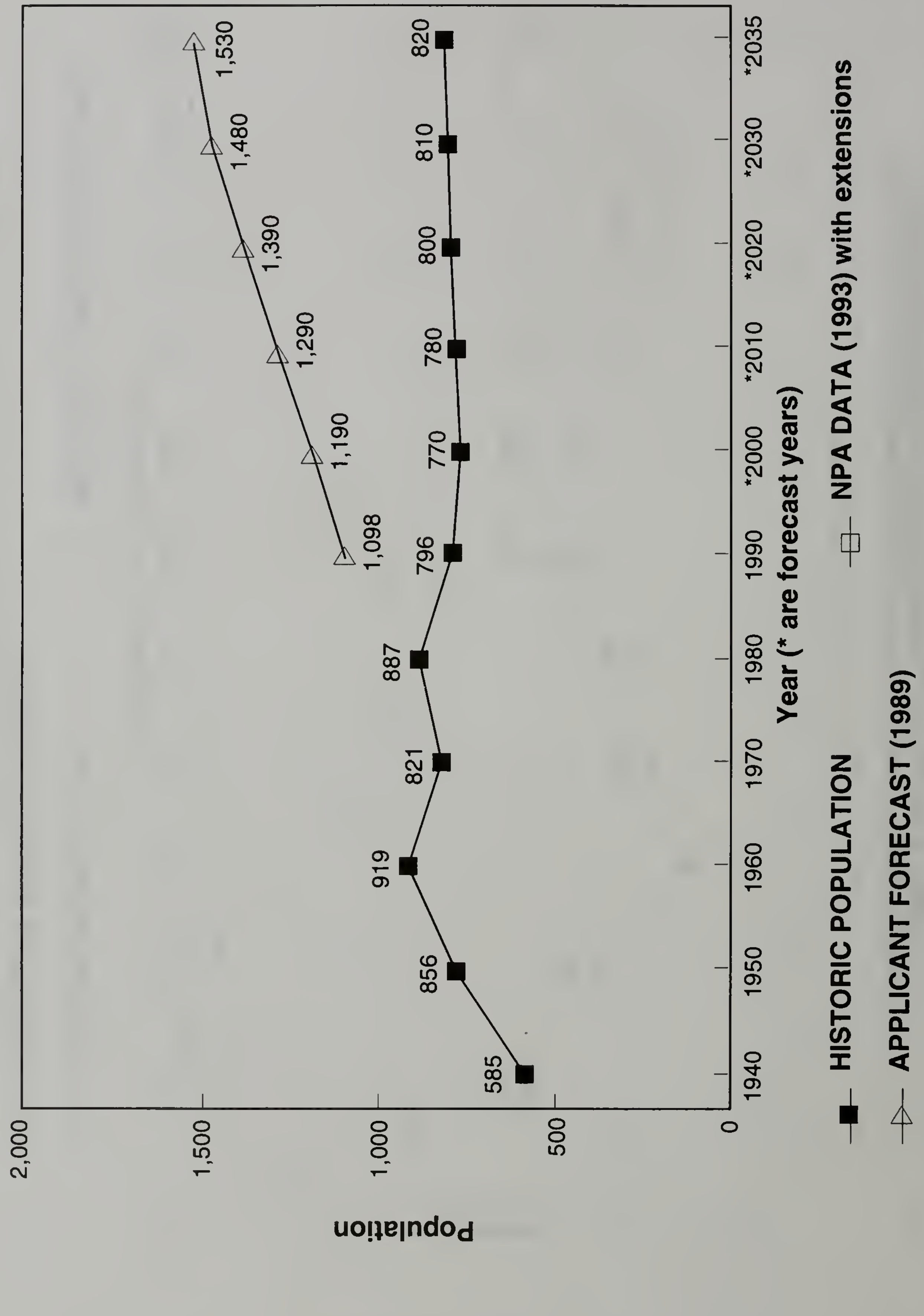
CHINOOK HISTORIC POPULATION AND TWO FORECASTS

Historic populations from Bur. of Census, Projections from Applicant and NPA DATA, INC.



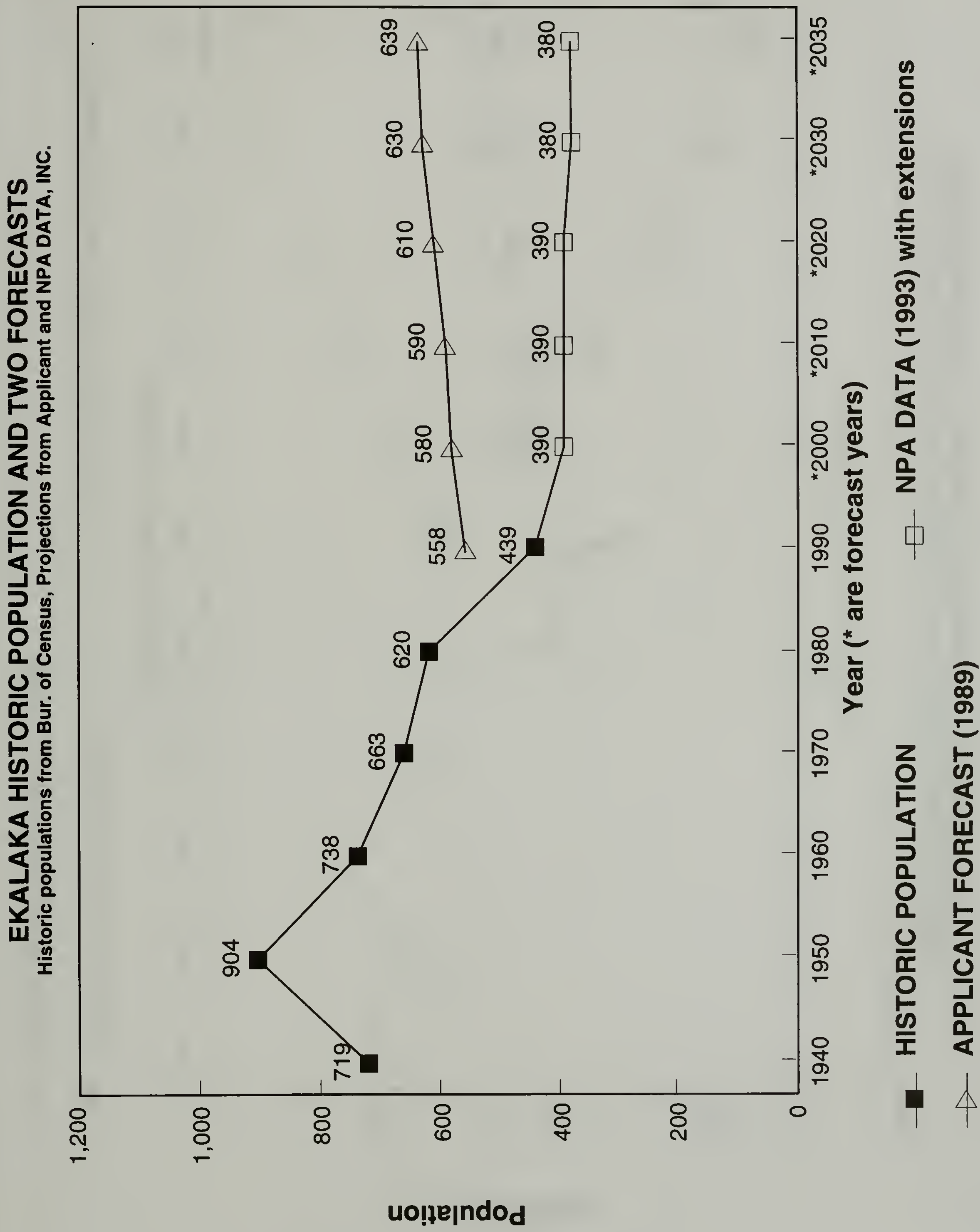
CIRCLE HISTORIC POPULATION AND TWO FORECASTS

Historic populations from Bur. of Census, Projections from Applicant and NPA DATA, INC.



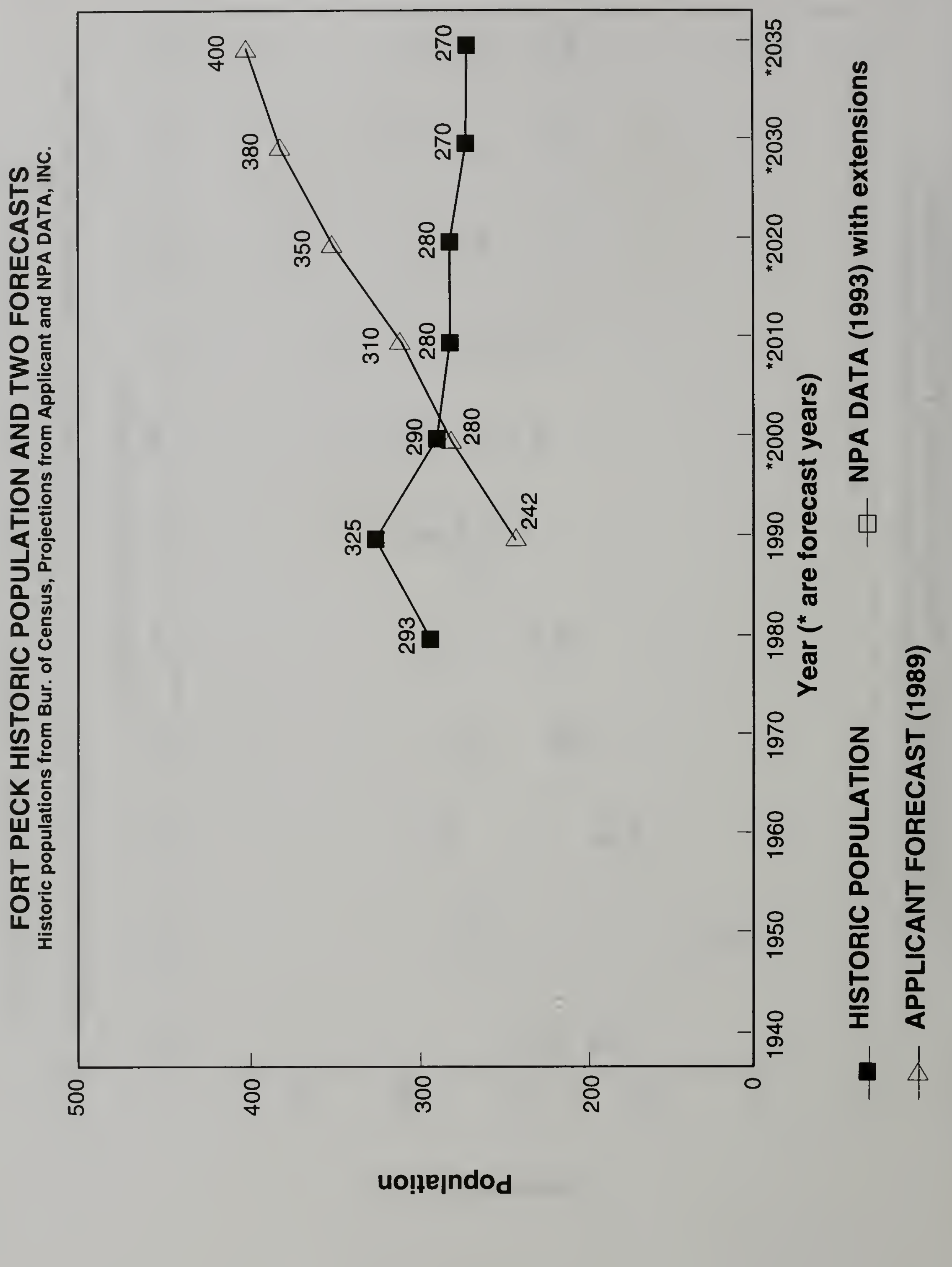
CULBERTSON HISTORIC POPULATION AND TWO FORECASTS

Historic populations from Bur. of Census, Projections from Applicant and NPA DATA, INC.



**EKALAKA HISTORIC POPULATION AND TWO FORECASTS**

Historic populations from Bur. of Census, Projections from Applicant and NPA DATA, INC.



FORT PECK HISTORIC POPULATION AND TWO FORECASTS

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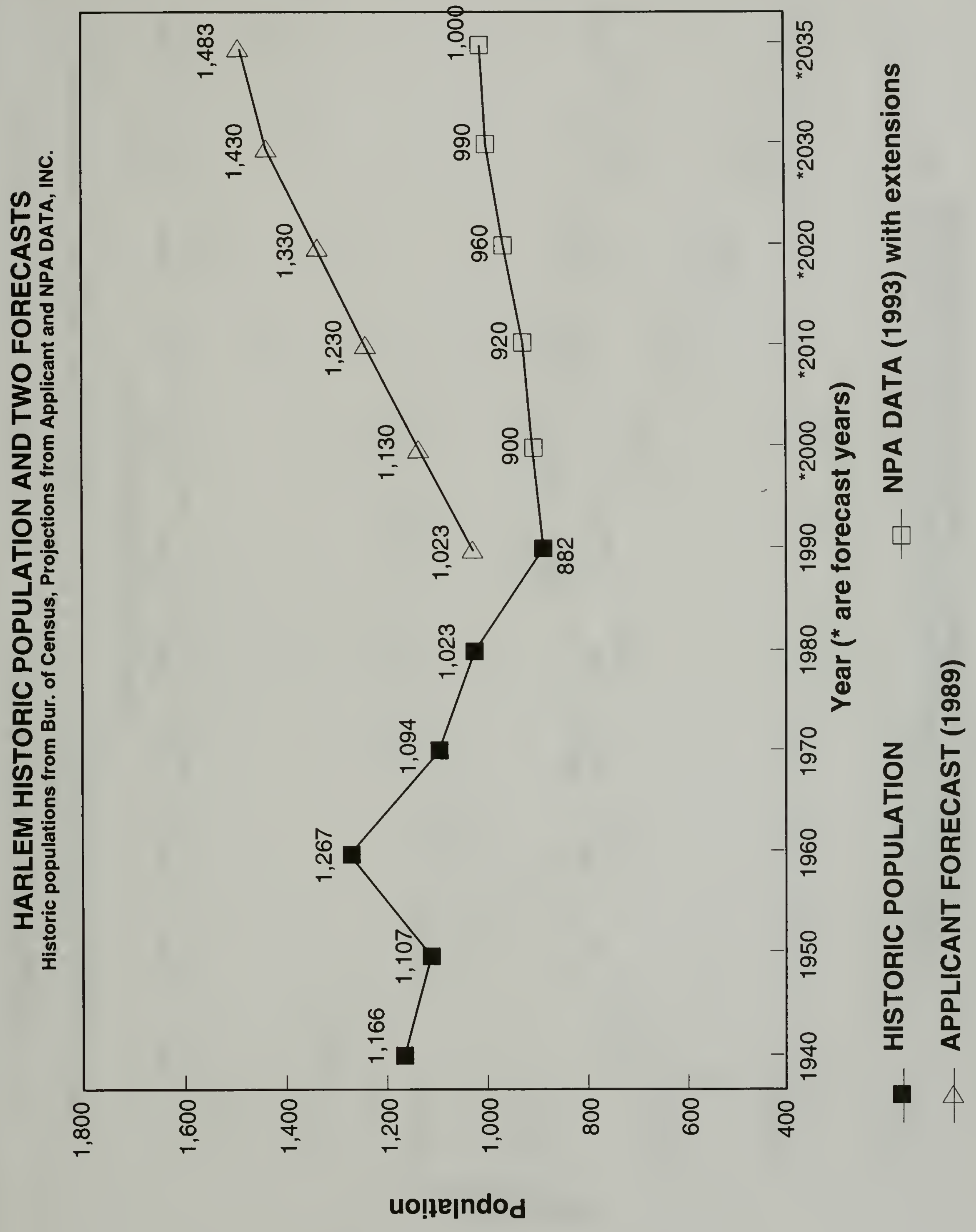
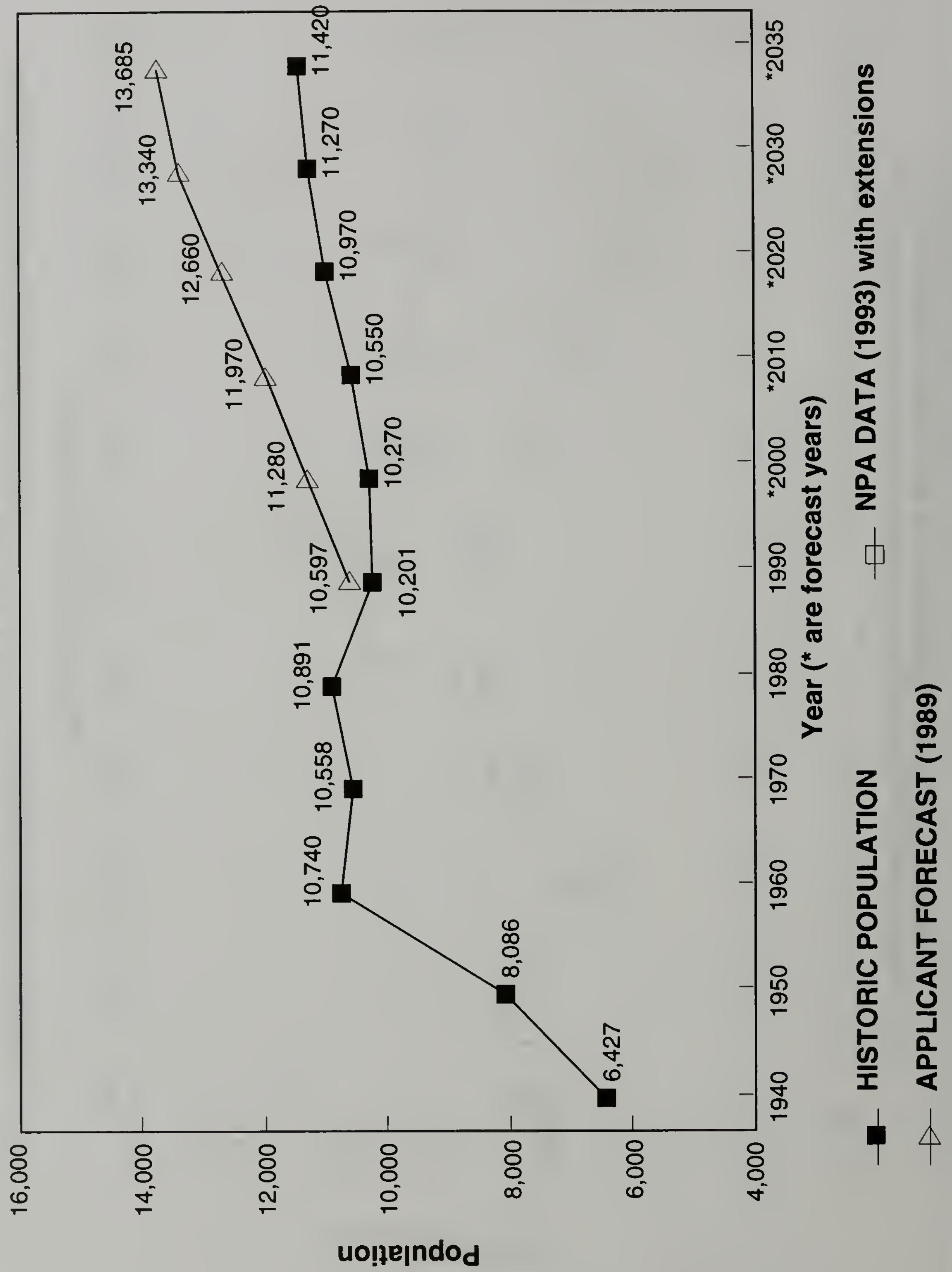


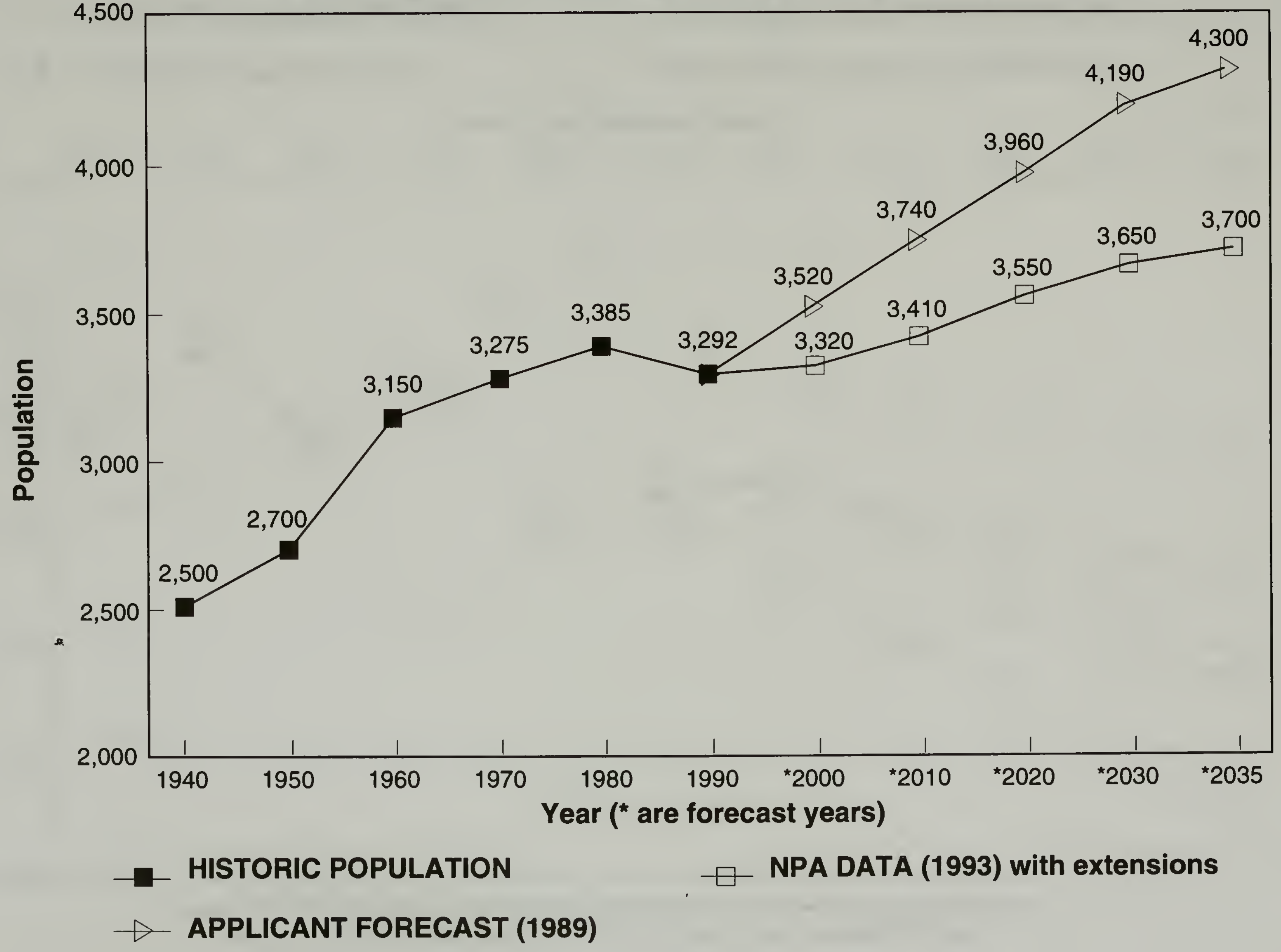
HARLEM HISTORIC POPULATION AND TWO FORECASTS

Historic populations from Bur. of Census, Projections from Applicant and NPA DATA, INC.



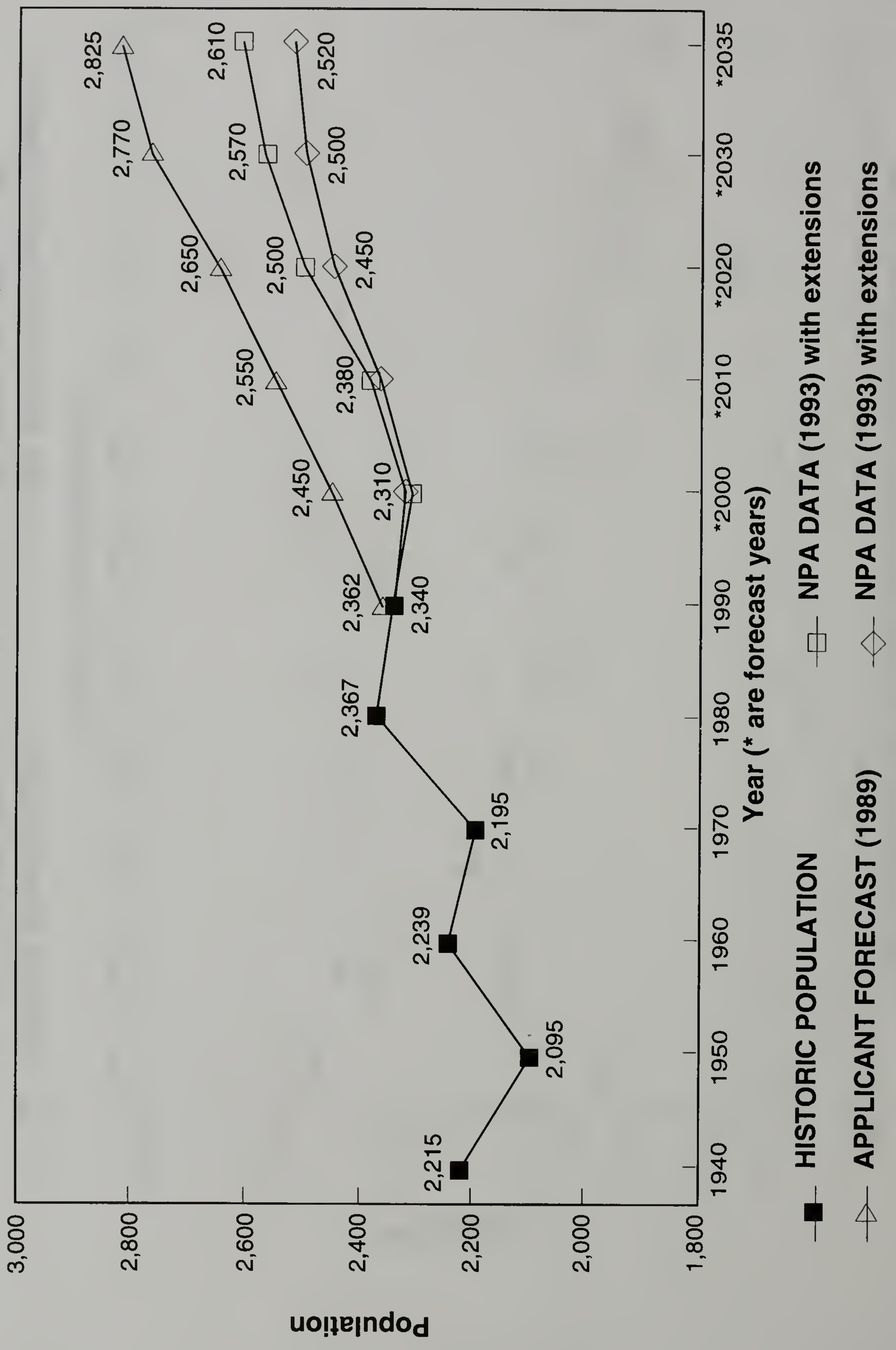
HAVRE HISTORIC POPULATION AND TWO FORECASTS

Historic populations from Bur. of Census, Projections from Applicant and NPA DATA, INC.



**HILL COUNTY WATER DISTRICT POPULATION AND TWO FORECASTS**

**Historic populations from Bur. of Census, Projections from Applicant and NPA DATA, INC.**

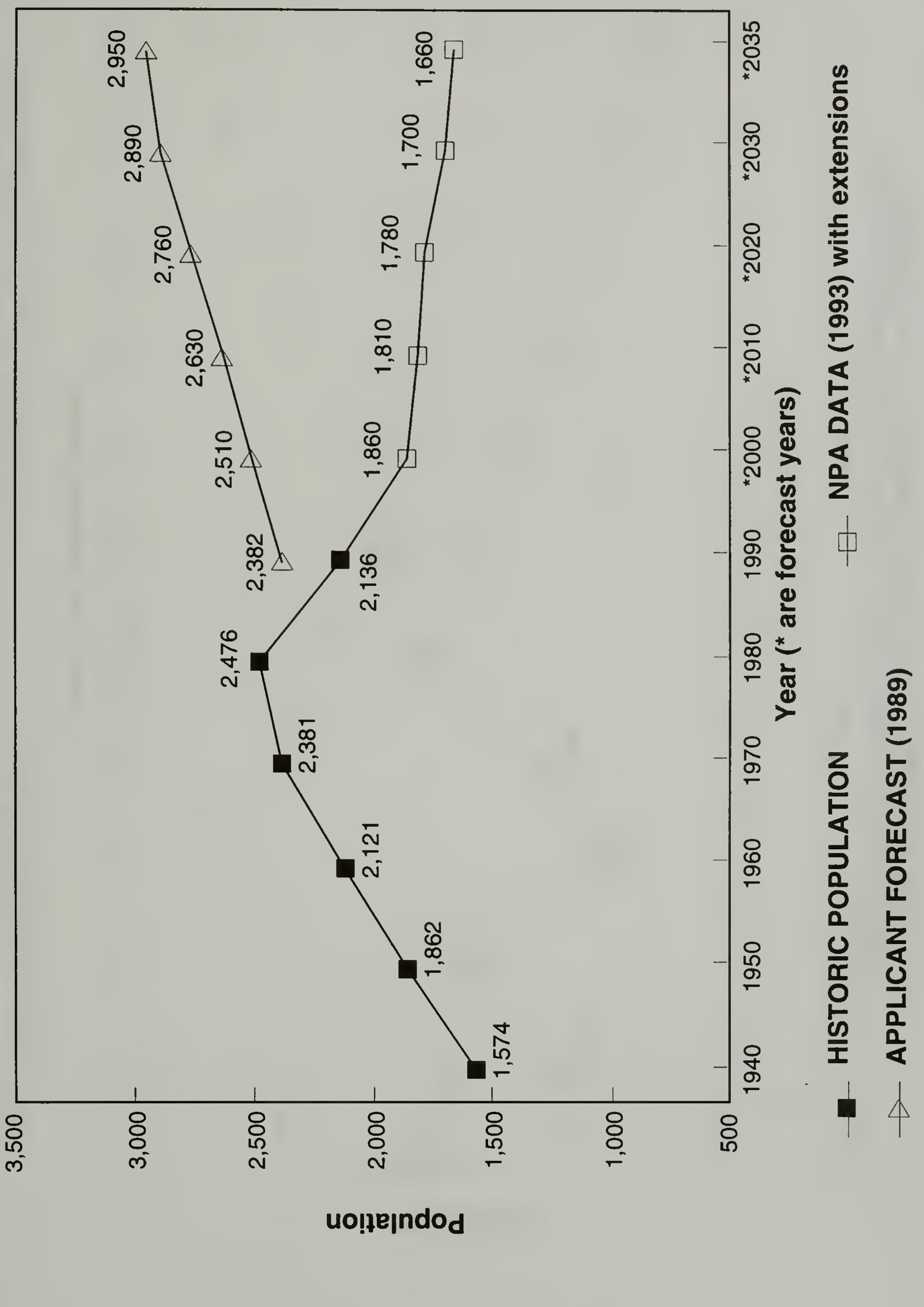


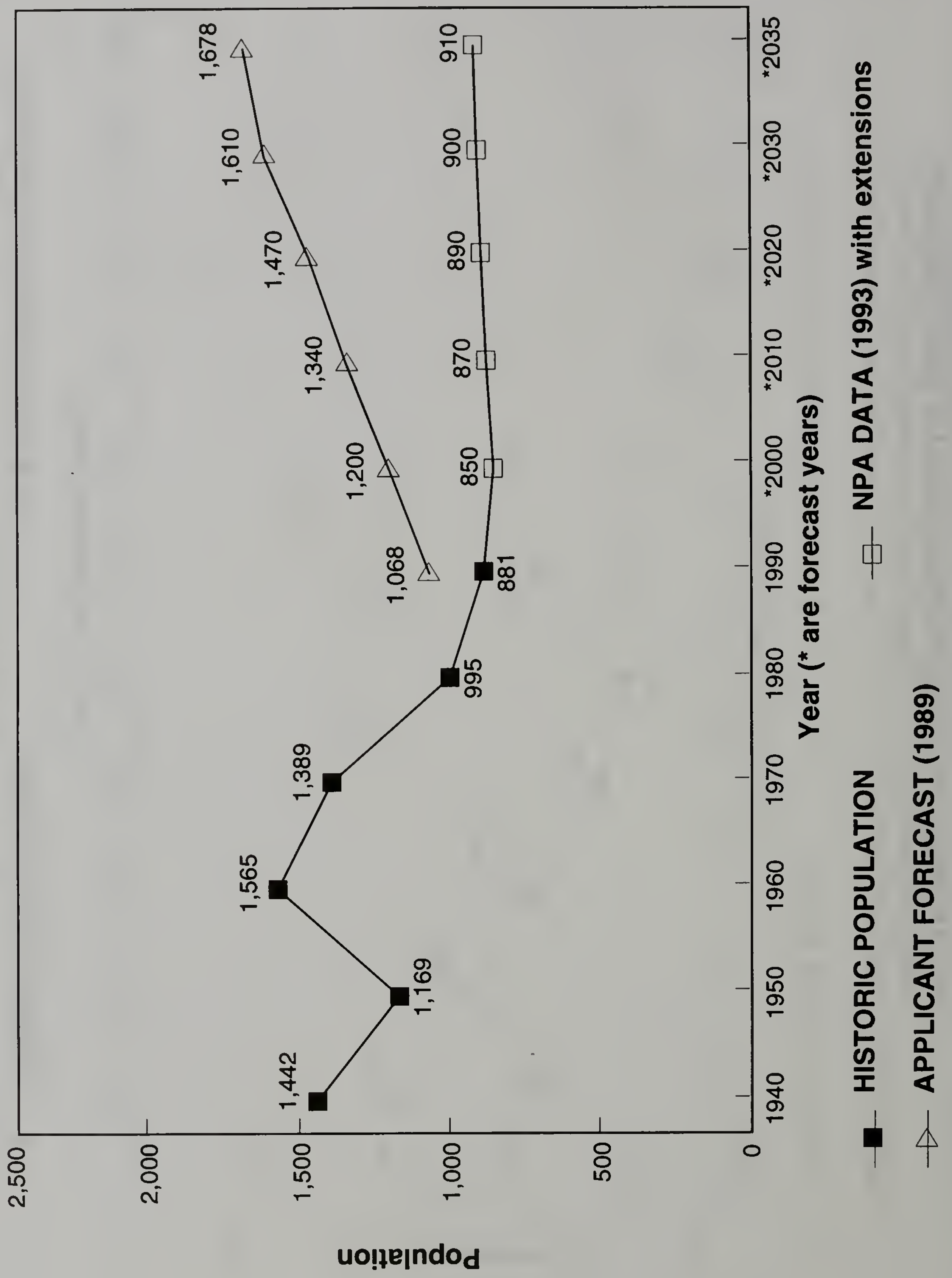
**MALTA HISTORIC POPULATION AND TWO FORECASTS**

Historic populations from Bur. of Census, Projections from Applicant and NPA DATA, INC.

## PLENTYWOOD HISTORIC POPULATION AND TWO FORECASTS

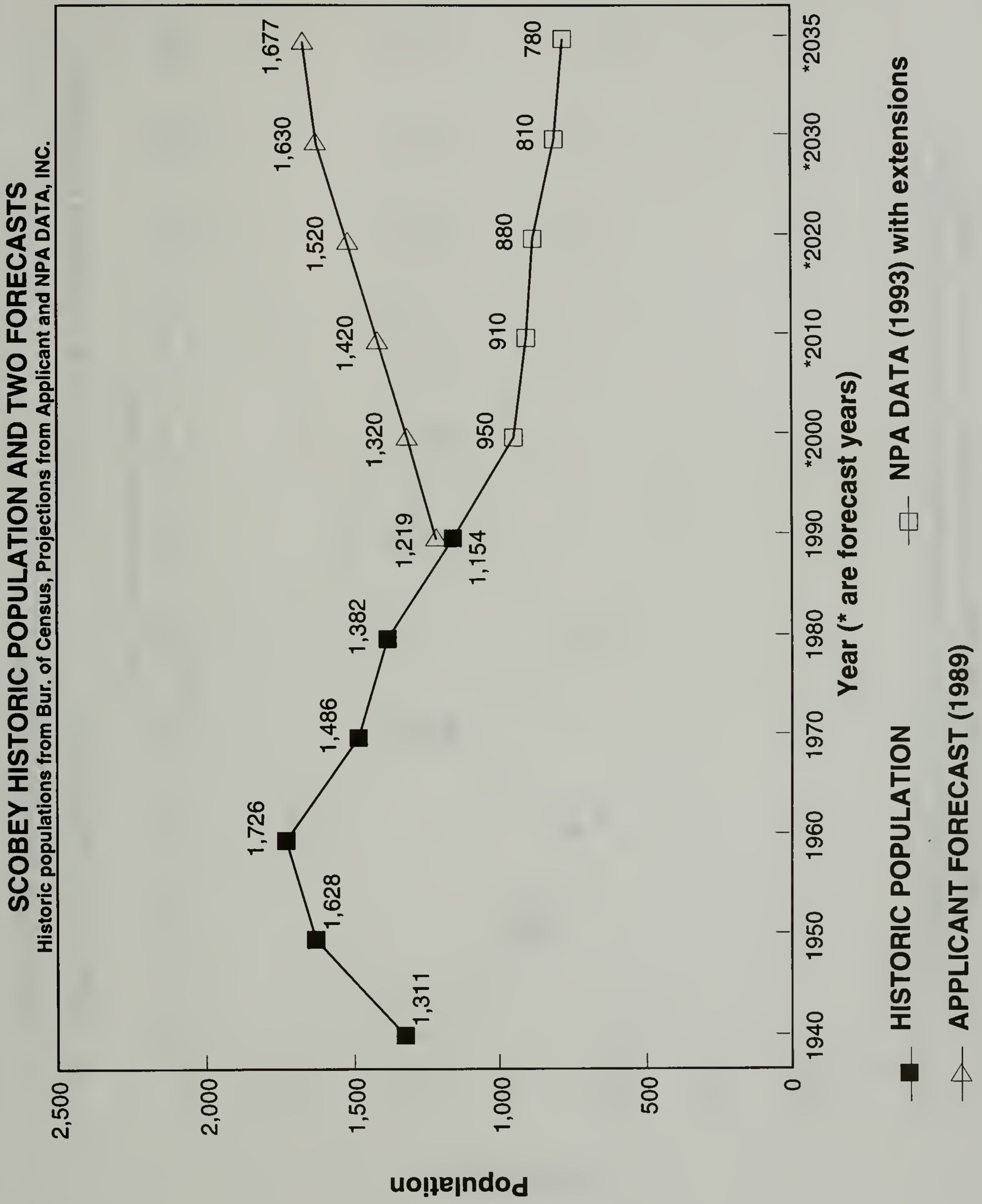
Historic populations from Bur. of Census, Projections from Applicant and NPA DATA, INC.





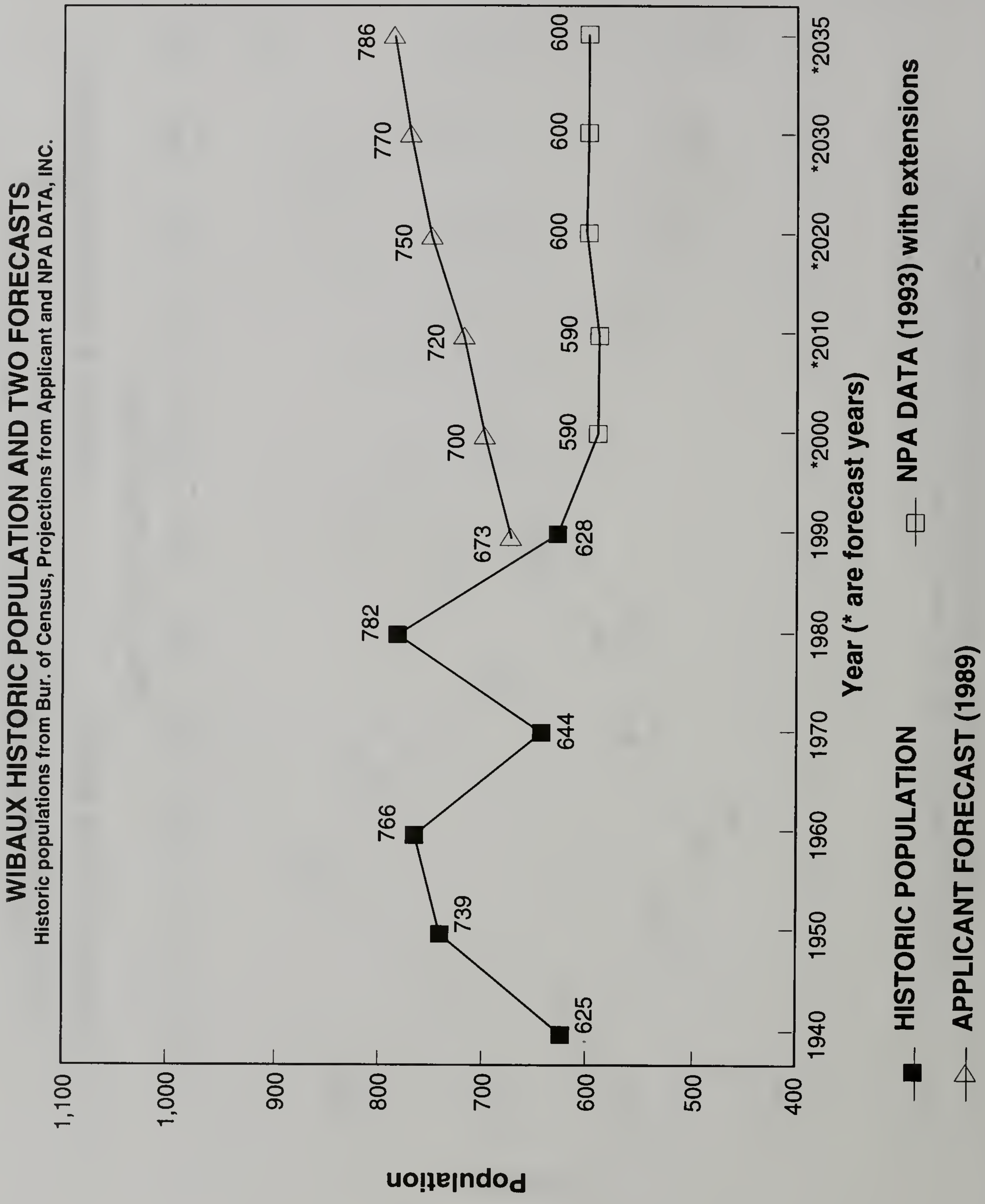
**POPLAR HISTORIC POPULATION AND TWO FORECASTS**

Historic populations from Bur. of Census, Projections from Applicant and NPA DATA, INC.



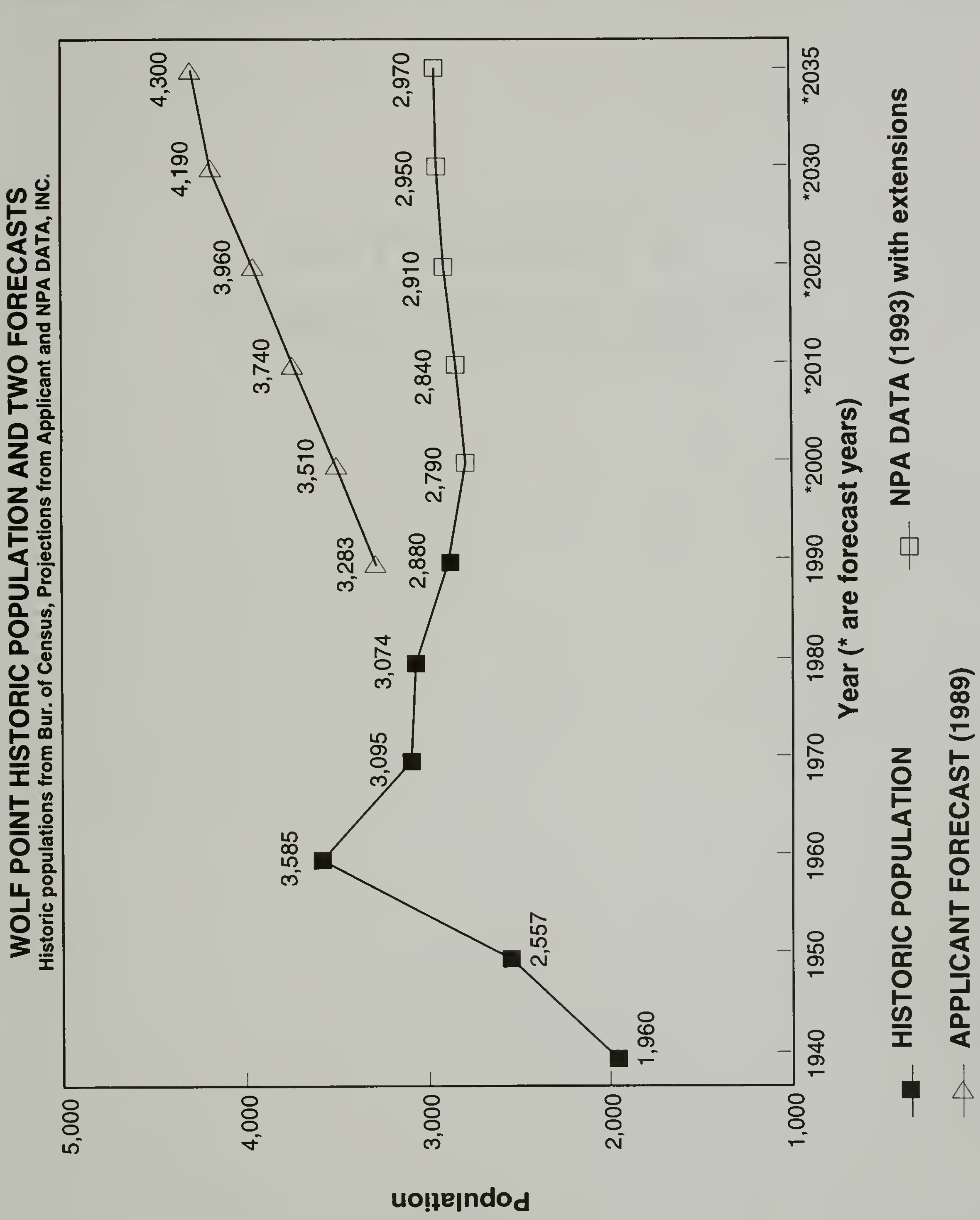
**SCOBEY HISTORIC POPULATION AND TWO FORECASTS**

Historic populations from Bur. of Census, Projections from Applicant and NPA DATA, INC.



WIBAUX HISTORIC POPULATION AND TWO FORECASTS

Historic populations from Bur. of Census, Projections from Applicant and NPA DATA, INC.



WOLF POINT HISTORIC POPULATION AND TWO FORECASTS

Historic populations from Bur. of Census, Projections from Applicant and NPA DATA, INC.

# APPENDIX L

## ECONOMIC AND FINANCIAL ANALYSIS LOWER MISSOURI RIVER BASIN

Tables L-1 and L-2 list the value of water for each of the proposed irrigation and municipal reservations. Consumptive use water values for the proposed irrigation projects are derived with methodology described in Goroski (1993) and the DNRC Methodology Manual (1991). These values are annualized differences between the net revenues (Tables L-5 and L-7) from the existing dryland farming or ranching operations and net revenues from the proposed irrigated alfalfa-barley farming operations.

Municipal water values are with the assumption that municipal water is worth at least what people are now paying for it. Municipal use consists of a variety of different uses. The lowest valued use is probably watering lawns. The value of water for other uses, such as for drinking and cooking, is much higher. DNRC used Hill County Water District's current rate of $2.68 per thousand gallons as an estimate of this value. The municipal water values shown in Tables L-1 and L-2 are the annualized present values of the proposed municipal uses valued at $2.68 per thousand gallons, less costs. Table L-3 shows the size of each municipal request in thousand gallons a year, the total annual cost, the cost per thousand gallons attributable to each municipal request, and the current cost per thousand gallons for each municipality.

Tables L-1 and L-2 compare consumptive use water values with instream water values. Instream water values are the sum of the recreation and hydropower production values (Table L-4). The value for hydropower production is based on lost kWh per acre-foot at downstream hydropower facilities, which is assumed to be approximately 516 kWh/af, and the cost of replacement power. The value of recreation, which depends on seasonal use, is higher during the summer and lower during the rest of the year. Therefore, the value of recreation when compared to year-round municipal use is one-sixth of the July-August value of water, plus five-sixths of the Rest-of-Year value of water. The recreation value when compared to the irrigation uses, which is a summer use, is a simple average of July-August and Rest-of-Year values. This analysis uses Duffield's recreational value (1990) for the middle Missouri and Marias/Teton subbasins in the upper Missouri River basin as an approximation of the recreational value in the lower Missouri River basin. These instream values are assumed to be basin-wide averages.

Tables L-1 and L-2 also provide sensitivity analyses of replacement power costs. The assumed cost for replacement power is based on rates of 5 and 10 cents/kWh. These sensitivity analyses affect both instream values as they relate to hydropower production and consumptive use values as they relate to additional power required by the proposed consumptive use projects. In other words, assuming 10 cents/kWh instead of 5 cents/kWh would decrease consumptive use water values if pumps are electrically powered, while instream values would increase because hydropower production becomes more valuable.

Table L-1. Comparison of water values for consumptive use and instream use ($/acft)

| Subbasin | 50 MILL (5 CENTS) PER KILOWATT HOUR REPLACEMENT COST | | | | | | | | | 100 MILL (10 CENTS) PER KILOWATT HOUR REPLACEMENT COST | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Drainage | CONSUMPTIVE VALUE | | | | INSTREAM | CONSUMPTIVE VALUE MINUS INSTREAM VALUE | | | | CONSUMPTIVE VALUE | | | | INSTREAM | CONSUMPTIVE VALUE MINUS INSTREAM VALUE | | | |
| Project | 10/10 | 8/10 | 6/10 | 4/10 | VALUE | 10/10 | 8/10 | 6/10 | 4/10 | 10/10 | 8/10 | 6/10 | 4/10 | VALUE | 10/10 | 8/10 | 6/10 | 4/10 |
| **Lower Missouri** | | | | | | | | | | | | | | | | | | |
| **Missouri River** | | | | | | | | | | | | | | | | | | |
| Circle | 657.40 | | | | 28.29 | 629.11 | | | | 630.39 | | | | 54.25 | 576.14 | | | |
| Culbartson | 657.40 | | | | 28.29 | 629.11 | | | | 630.39 | | | | 54.25 | 576.14 | | | |
| Fort Peck | 657.40 | | | | 28.29 | 629.11 | | | | 630.39 | | | | 54.25 | 576.14 | | | |
| Poplar | 657.40 | | | | 28.29 | 629.11 | | | | 630.39 | | | | 54.25 | 576.14 | | | |
| Wolf Point | 657.40 | | | | 28.29 | 629.11 | | | | 630.39 | | | | 54.25 | 576.14 | | | |
| VA-01 | 8.47 | -8.81 | -23.48 | -40.20 | 29.68 | -21.21 | -38.49 | -53.17 | -69.89 | 8.47 | -8.81 | -23.48 | -40.20 | 55.64 | -47.17 | -64.45 | -79.13 | -95.85 |
| VA-02 | 0.80 | -13.98 | -26.42 | -40.52 | 29.68 | -28.88 | -43.66 | -56.10 | -70.20 | -27.51 | -42.28 | -54.72 | -68.82 | 55.64 | -83.15 | -97.92 | -110.36 | -124.46 |
| VA-03 | 21.42 | 5.03 | -8.53 | -24.15 | 29.68 | -8.26 | -24.65 | -38.22 | -53.83 | 1.52 | -14.87 | -28.44 | -44.06 | 55.64 | -54.13 | -70.52 | -84.08 | -99.70 |
| VA-231 | 9.49 | -7.57 | -22.00 | -38.58 | 29.68 | -20.20 | -37.25 | -51.68 | -68.26 | -5.49 | -22.55 | -36.97 | -53.55 | 55.64 | -61.13 | -78.19 | -92.62 | -109.19 |
| MC-01 | 33.09 | 17.61 | 4.27 | -11.12 | 29.68 | 3.40 | -12.07 | -25.41 | -40.80 | 20.59 | 5.12 | -8.22 | -23.61 | 55.64 | -35.05 | -50.52 | -63.86 | -79.25 |
| MC-03 | 40.02 | 22.29 | 7.14 | -9.84 | 29.68 | 10.34 | -7.39 | -22.55 | -39.52 | 27.86 | 10.13 | -5.02 | -22.00 | 55.64 | -27.78 | -45.51 | -60.67 | -77.64 |
| MC-04 | 25.20 | 6.86 | -8.61 | -25.81 | 29.68 | -4.48 | -22.82 | -38.29 | -55.49 | 15.66 | -2.69 | -18.16 | -35.35 | 55.64 | -39.99 | -58.33 | -73.80 | -91.00 |
| MC-05 | 17.52 | 0.74 | -13.41 | -29.70 | 29.68 | -12.16 | -28.94 | -43.09 | -59.39 | 0.99 | -15.79 | -29.94 | -46.23 | 55.64 | -54.65 | -71.43 | -85.58 | -101.88 |
| MC-5A | 26.89 | 8.95 | -6.33 | -23.45 | 29.68 | -2.79 | -20.73 | -36.01 | -53.13 | 15.66 | -2.28 | -17.56 | -34.68 | 55.64 | -39.98 | -57.92 | -73.20 | -90.32 |
| MC-06 | 44.59 | 26.66 | 11.40 | -5.70 | 29.68 | 14.91 | -3.02 | -18.28 | -35.38 | 33.20 | 15.27 | 0.01 | -17.09 | 55.64 | -22.44 | -40.37 | -55.64 | -72.74 |
| MC-6A | 20.48 | 2.28 | -13.08 | -30.26 | 29.68 | -9.21 | -27.40 | -42.76 | -59.94 | 11.45 | -6.75 | -22.11 | -39.29 | 55.64 | -44.20 | -62.39 | -77.75 | -94.93 |
| MC-08 | 14.28 | -1.76 | -15.08 | -30.36 | 29.68 | -15.40 | -31.44 | -44.76 | -60.04 | -7.99 | -24.03 | -37.34 | -52.62 | 55.64 | -63.63 | -79.67 | -92.98 | -108.27 |
| MC-09 | 40.07 | 22.31 | 7.13 | -9.87 | 29.68 | 10.39 | -7.38 | -22.55 | -39.55 | 28.58 | 10.81 | -4.36 | -21.36 | 55.64 | -27.07 | -44.83 | -60.00 | -77.00 |
| MC-9A | -0.74 | -18.45 | -33.58 | -50.56 | 29.68 | -30.42 | -48.13 | -63.26 | -80.24 | -0.74 | -18.45 | -33.58 | -50.56 | 55.64 | -56.38 | -74.09 | -89.22 | -106.20 |
| MC-10 | 8.45 | -8.03 | -21.90 | -37.83 | 29.68 | -21.24 | -37.71 | -51.58 | -67.51 | -9.80 | -26.28 | -40.15 | -56.08 | 55.64 | -65.44 | -81.92 | -95.79 | -111.72 |
| MC-11 | 19.40 | 2.69 | -11.71 | -28.24 | 29.68 | -10.28 | -26.99 | -41.39 | -57.93 | 2.70 | -14.01 | -28.41 | -44.94 | 55.64 | -52.95 | -69.65 | -84.06 | -100.59 |
| MC-12 | 7.07 | -9.12 | -22.53 | -37.95 | 29.68 | -22.61 | -38.80 | -52.21 | -67.63 | -13.69 | -29.88 | -43.29 | -58.71 | 55.64 | -69.34 | -85.52 | -98.94 | -114.35 |
| MC-99 | 24.94 | 8.68 | -4.79 | -20.28 | 29.68 | -4.74 | -21.01 | -34.47 | -49.96 | 3.09 | -13.18 | -26.64 | -42.13 | 55.64 | -52.56 | -68.82 | -82.28 | -97.77 |
| RI-01 | 25.92 | 9.00 | -5.59 | -22.36 | 29.68 | -3.76 | -20.68 | -35.27 | -52.04 | 8.55 | -8.37 | -22.96 | -39.73 | 55.64 | -47.09 | -64.02 | -78.60 | -95.37 |
| RI-02 | 38.04 | 19.97 | 4.99 | -12.22 | 29.68 | 8.35 | -9.71 | -24.69 | -41.90 | 13.98 | -4.09 | -19.07 | -36.28 | 55.64 | -41.67 | -59.73 | -74.71 | -91.92 |
| RI-03 | 38.69 | 21.35 | 6.84 | -9.62 | 29.68 | 9.01 | -8.33 | -22.84 | -39.30 | 10.36 | -6.98 | -21.49 | -37.95 | 55.64 | -45.29 | -62.62 | -77.13 | -93.59 |
| RI-04 | 40.70 | 21.54 | 5.31 | -13.29 | 29.68 | 11.02 | -8.14 | -24.37 | -42.97 | 23.83 | 4.67 | -11.56 | -30.16 | 55.64 | -31.81 | -50.97 | -67.20 | -85.80 |
| RI-05 | 23.31 | 3.89 | -12.66 | -31.41 | 29.68 | -6.37 | -25.79 | -42.34 | -61.09 | 7.44 | -11.98 | -28.53 | -47.28 | 55.64 | -48.20 | -67.62 | -84.17 | -102.93 |
| RI-06 | 33.53 | 13.71 | -3.23 | -22.20 | 29.68 | 3.85 | -15.97 | -32.91 | -51.89 | 19.62 | -0.21 | -17.14 | -36.12 | 55.64 | -36.03 | -55.85 | -72.79 | -91.76 |
| RI-07 | -3.42 | -19.79 | -33.60 | -49.26 | 29.68 | -33.10 | -49.47 | -63.28 | -78.94 | -34.04 | -50.40 | -64.21 | -79.87 | 55.64 | -89.68 | -106.04 | -119.86 | -135.52 |
| RI-08 | 9.31 | -6.31 | -19.84 | -35.14 | 29.68 | -20.37 | -35.99 | -49.52 | -64.82 | -16.26 | -31.88 | -45.41 | -60.71 | 55.64 | -71.90 | -87.52 | -101.05 | -116.36 |
| RI-09 | 15.14 | -2.76 | -17.63 | -34.68 | 29.68 | -14.54 | -32.44 | -47.31 | -64.36 | -10.27 | -28.18 | -43.04 | -60.09 | 55.64 | -65.92 | -83.82 | -98.68 | -115.74 |
| RI-10 | 31.69 | 14.16 | -0.44 | -17.10 | 29.68 | 2.01 | -15.52 | -30.13 | -46.78 | 4.91 | -12.62 | -27.23 | -43.88 | 55.64 | -50.73 | -68.26 | -82.87 | -99.53 |
| RI-11A | 33.71 | 13.89 | -3.04 | -22.01 | 29.68 | 4.02 | -15.79 | -32.73 | -51.70 | 20.87 | 1.05 | -15.88 | -34.85 | 55.64 | -34.77 | -54.59 | -71.52 | -90.49 |
| RI-11 | 52.86 | 33.92 | 17.88 | -0.49 | 29.68 | 23.18 | 4.24 | -11.81 | -30.17 | 33.74 | 14.79 | -1.25 | -19.62 | 55.64 | -21.90 | -40.85 | -56.89 | -75.26 |
| RI-12 | 39.37 | 19.94 | 3.38 | -15.39 | 29.68 | 9.69 | -9.74 | -26.31 | -45.07 | 24.13 | 4.70 | -11.87 | -30.63 | 55.64 | -31.52 | -50.95 | -67.51 | -86.28 |
| RI-13 | 33.36 | 13.40 | -3.61 | -22.69 | 29.68 | 3.68 | -16.28 | -33.29 | -52.37 | 20.67 | 0.71 | -16.31 | -35.38 | 55.64 | -34.98 | -54.93 | -71.95 | -91.03 |
| RI-14 | 31.29 | 12.89 | -2.59 | -20.38 | 29.68 | 1.61 | -16.79 | -32.28 | -50.06 | 10.44 | -7.96 | -23.44 | -41.23 | 55.64 | -45.20 | -63.60 | -79.09 | -96.87 |
| RI-15 | 10.19 | -7.46 | -22.16 | -38.94 | 29.68 | -19.49 | -37.14 | -51.84 | -68.62 | -15.73 | -33.39 | -48.08 | -64.87 | 55.64 | -71.38 | -89.03 | -103.73 | -120.51 |
| CBI-1 | 48.18 | 29.54 | 13.78 | -4.29 | 29.68 | 18.49 | -0.14 | -15.90 | -33.97 | 19.76 | 1.13 | -14.63 | -32.70 | 55.64 | -35.88 | -54.51 | -70.28 | -88.35 |
| CBI-2 | 16.52 | -0.05 | -14.27 | -30.30 | 29.68 | -13.16 | -29.73 | -43.95 | -59.98 | -2.79 | -19.36 | -33.57 | -49.61 | 55.64 | -58.43 | -75.00 | -89.22 | -105.25 |
| CBI-3 | 27.49 | 10.26 | -4.65 | -21.61 | 29.68 | -2.19 | -19.42 | -34.33 | -51.29 | 10.33 | -6.90 | -21.81 | -38.77 | 55.64 | -45.31 | -62.54 | -77.45 | -94.41 |
| CBI-4 | -5.28 | -18.00 | -28.86 | -40.99 | 29.68 | -34.96 | -47.68 | -58.54 | -70.67 | -22.23 | -34.95 | -45.81 | -57.94 | 55.64 | -77.87 | -90.59 | -101.45 | -113.58 |
| CBI-5 | 8.64 | -8.74 | -23.41 | -40.32 | 29.68 | -21.04 | -38.43 | -53.09 | -70.00 | -6.72 | -24.11 | -38.78 | -55.68 | 55.64 | -62.37 | -79.75 | -94.42 | -111.33 |
| CBI-6 | 23.37 | 5.80 | -8.77 | -25.51 | 29.68 | -6.31 | -23.88 | -38.45 | -55.19 | 1.02 | -16.55 | -31.12 | -47.85 | 55.64 | -54.62 | -72.19 | -86.76 | -103.50 |
| CBI-7 | -18.70 | -36.70 | -51.86 | -69.36 | 29.68 | -48.38 | -66.38 | -81.54 | -99.05 | -32.21 | -50.21 | -65.38 | -82.88 | 55.64 | -87.86 | -105.85 | -121.02 | -138.52 |
| CBI-8 | 12.49 | -1.13 | -13.10 | -26.29 | 29.68 | -17.19 | -30.81 | -42.78 | -55.97 | -16.85 | -30.47 | -42.44 | -55.63 | 55.64 | -72.49 | -86.11 | -98.08 | -111.27 |
| CBI-9 | -2.89 | -16.79 | -29.20 | -42.64 | 29.68 | -32.57 | -46.47 | -58.88 | -72.32 | -35.41 | -49.32 | -61.72 | -75.16 | 55.64 | -91.05 | -104.96 | -117.36 | -130.81 |
| CBI-10 | 13.59 | -1.24 | -14.36 | -28.73 | 29.68 | -16.09 | -30.92 | -44.04 | -58.41 | -10.74 | -25.56 | -38.68 | -53.06 | 55.64 | -66.38 | -81.21 | -94.33 | -108.70 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CBI-11 | 4.96 | -10.01 | -23.35 | -37.75 | 29.68 | -24.73 | -39.69 | -53.04 | -67.43 | -23.22 | -38.18 | -51.53 | -65.92 | 55.64 | -78.86 | -93.82 | -107.17 | -121.56 |
| CBI-12 | -12.32 | -26.03 | -38.13 | -51.39 | 29.68 | -42.00 | -55.71 | -67.82 | -81.07 | -42.23 | -55.95 | -68.05 | -81.30 | 55.64 | -97.87 | -111.59 | -123.69 | -136.94 |
| CBI-J3 | -19.92 | -30.82 | -40.14 | -50.81 | 29.68 | -49.60 | -60.50 | -69.82 | -80.50 | -55.95 | -66.85 | -76.17 | -86.85 | 55.64 | -111.59 | -122.49 | -131.81 | -142.49 |
| CBI-14 | 37.50 | 19.70 | 4.45 | -13.30 | 29.68 | 7.81 | -9.98 | -25.23 | -42.98 | 24.09 | 6.30 | -8.96 | -26.71 | 55.64 | -31.56 | -49.35 | -64.60 | -82.35 |
| CBI-15 | 12.62 | -0.60 | -12.67 | -25.68 | 29.68 | -17.06 | -30.29 | -42.35 | -55.36 | -10.53 | -23.75 | -35.82 | -48.83 | 55.64 | -66.17 | -79.40 | -91.46 | -104.47 |
| CBI-16 | 19.04 | 3.05 | -10.72 | -26.09 | 29.68 | -10.64 | -26.64 | -40.40 | -55.77 | -3.87 | -19.86 | -33.62 | -48.99 | 55.64 | -59.51 | -75.50 | -89.27 | -104.64 |
| CBI-17 | 27.92 | 11.40 | -2.52 | -18.14 | 29.68 | -1.77 | -18.28 | -32.20 | -47.82 | 6.73 | -9.79 | -23.70 | -39.32 | 55.64 | -48.91 | -65.43 | -79.35 | -94.97 |
| CBI-18 | 0.51 | -13.79 | -26.19 | -40.23 | 29.68 | -29.18 | -43.48 | -55.88 | -69.91 | -30.35 | -44.65 | -57.05 | -71.09 | 55.64 | -86.00 | -100.30 | -112.70 | -126.73 |
| CBI-19 | 41.07 | 23.67 | 8.66 | -8.64 | 29.68 | 11.39 | -6.02 | -21.02 | -38.32 | 26.95 | 9.54 | -5.46 | -22.76 | 55.64 | -28.69 | -46.10 | -61.10 | -78.41 |
| CBI-20 | 27.90 | 10.61 | -4.36 | -21.36 | 29.68 | -1.79 | -19.07 | -34.04 | -51.04 | 27.90 | 10.61 | -4.36 | -21.36 | 55.64 | -27.75 | -45.03 | -60.00 | -77.00 |
| CBI-21 | 13.69 | -0.72 | -14.32 | -29.35 | 29.68 | -15.99 | -30.40 | -44.01 | -59.03 | -6.19 | -20.60 | -34.21 | -49.23 | 55.64 | -61.83 | -76.24 | -89.85 | -104.88 |
| **Poplar River** | | | | | | | | | | | | | | | | | | |
| Scobey | 657.40 | | | | 28.29 | 629.11 | | | | 630.39 | | | | 54.25 | 576.14 | | | |
| DA-21WS | 25.04 | 9.21 | -0.99 | -16.00 | 29.68 | -4.64 | -20.48 | -30.67 | -45.68 | 25.04 | 9.21 | -0.99 | -16.00 | 55.64 | -30.60 | -46.44 | -56.63 | -71.64 |
| DA-31 | 51.94 | 9.77 | -25.45 | -65.93 | 29.68 | 22.26 | -19.91 | -55.13 | -95.61 | 0.88 | -41.29 | -76.51 | -116.99 | 55.64 | -54.76 | -96.93 | -132.15 | -172.64 |
| DA-32 | 58.05 | 12.22 | -26.44 | -69.47 | 29.68 | 28.37 | -17.46 | -56.12 | -99.15 | 35.41 | -10,42 | -49.08 | -92.11 | 55.64 | -20.23 | -66.06 | -104.72 | -147.76 |
| DA-51 | 82.14 | 45.67 | 14.32 | -21.25 | 29.68 | 52.46 | 15.99 | -15.36 | -50.93 | 32.99 | -3.48 | -34.82 | -70.40 | 55.64 | -22.65 | -59.12 | -90.47 | -126.04 |
| DA-71 | 112.37 | 70.47 | 35.76 | -4.15 | 29.68 | 82.69 | 40.79 | 6.08 | -33.83 | 56.82 | 14.92 | -19.79 | -59.70 | 55.64 | 1.18 | -40.72 | -75.43 | -115.34 |
| DA-131WS | -1.17 | -27.70 | -44.79 | -69.94 | 29.68 | -30.85 | -57.38 | -74.47 | -99.63 | -1.17 | -27.70 | -44.79 | -69.94 | 55.64 | -56.81 | -83.34 | -100.43 | -125.59 |
| DA-151 | 124.72 | 80.20 | 42.25 | -0.74 | 29.68 | 95.04 | 50.52 | 12.57 | -30.42 | 87.81 | 43.29 | 5.34 | -37.65 | 55.64 | 32.17 | -12.35 | -50.30 | -93.30 |
| DA-152WS | 45.95 | 17.45 | -0.90 | -27.92 | 29.68 | 16.27 | -12.23 | -30.59 | -57.60 | 45.95 | 17.45 | -0.90 | -27.92 | 55.64 | -9.69 | -38.19 | -56.55 | -83.57 |
| DA-153WS | -1.14 | -27.02 | -43.68 | -68.22 | 29.68 | -30.82 | -56.70 | -73.36 | -97.90 | -1.14 | -27.02 | -43.68 | -68.22 | 55.64 | -56.78 | -82.66 | -99.33 | -123.86 |
| DA-161 | -54.46 | -95.33 | -129.53 | -168.29 | 29.68 | -84.14 | -125.01 | -159.21 | -197.97 | -84.99 | -125.86 | -160.06 | -198.82 | 55.64 | -140.63 | -181.50 | -215.70 | -254.47 |
| DA-181WS | 8.20 | -18.00 | -34.88 | -59.73 | 29.68 | -21.48 | -47.69 | -64.56 | -89.41 | 8.20 | -18.00 | -34.88 | -59.73 | 55.64 | -47.44 | -73.65 | -90.52 | -115.37 |
| DA-182WS | 39.55 | 13.64 | -3.04 | -27.60 | 29.68 | 9.87 | -16.04 | -32.72 | -57.29 | 39.55 | 13.64 | -3.04 | -27.60 | 55.64 | -16.09 | -42.00 | -58.68 | -83.25 |
| DA-211 | 32.56 | -3.60 | -35.78 | -70.64 | 29.68 | 2.88 | -33.28 | -65.46 | -100.32 | 32.56 | -3.60 | -35.78 | -70.64 | 55.64 | -23.08 | -59.25 | -91.43 | -126.28 |
| DA-221 | 142.99 | 96.39 | 57.03 | 12.98 | 29.68 | 113.31 | 66.71 | 27.35 | -16.70 | 116.70 | 70.10 | 30.74 | -13.32 | 55.64 | 61.06 | 14.46 | -24.90 | -68.96 |
| DA-251 | 88.88 | 42.53 | 3.27 | -40.85 | 29.68 | 59.20 | 12.85 | -26.41 | -70.54 | 88.88 | 42.53 | 3.27 | -40.85 | 55.64 | 33.24 | -13.11 | -52.37 | -96.50 |
| DA-252 | 96.71 | 54.21 | 18.41 | -22.92 | 29.68 | 67.03 | 24.53 | -11.27 | -52.60 | 96.71 | 54.21 | 18.41 | -22.92 | 55.64 | 41.07 | -1.43 | -37.24 | -78.56 |
| DA-261 | 79.64 | 37.06 | 1.10 | -40.28 | 29.68 | 49.96 | 7.38 | -28.58 | -69.96 | 37.49 | -5.09 | -41.05 | -82.43 | 55.64 | -18.15 | -60.73 | -96.69 | -138.07 |
| DA-281 | -55.54 | -87.94 | -115.82 | -146.87 | 29.68 | -85.22 | -117.63 | -145.51 | -176.55 | -126.34 | -158.74 | -186.62 | -217.67 | 55.64 | -181.98 | -214.38 | -242.26 | -273.31 |
| DA-291WS | -16.65 | -42.91 | -59.81 | -84.70 | 29.68 | -46.33 | -72.59 | -89.49 | -114.38 | -16.65 | -42.91 | -59.81 | -84.70 | 55.64 | -72.29 | -98.55 | -115.46 | -140.35 |
| DA-341 | 98.78 | 53.37 | 15.14 | -27.40 | 29.68 | 69.10 | 23.69 | -14.54 | -57.08 | 98.78 | 53.37 | 15.14 | -27.40 | 55.64 | 43.13 | -2.27 | -40.50 | -83.04 |
| DA-371WS | 30.05 | 11.05 | -1.19 | -19.20 | 29.68 | 0.36 | -18.64 | -30.87 | -48.88 | 30.05 | 11.05 | -1.19 | -19.20 | 55.64 | -25.60 | -44.60 | -56.83 | -74.84 |
| **Milk** | | | | | | | | | | | | | | | | | | |
| **Milk River** | | | | | | | | | | | | | | | | | | |
| Chinook | 657.40 | | | | 28.29 | 629.11 | | | | 630.39 | | | | 54.25 | 576.14 | | | |
| Harlem | 657.40 | | | | 28.29 | 629.11 | | | | 630.39 | | | | 54.25 | 576.14 | | | |
| Havre | 657.40 | | | | 28.29 | 629.11 | | | | 630.39 | | | | 54.25 | 576.14 | | | |
| Hill County W.D. | 657.40 | | | | 28.29 | 629.11 | | | | 630.39 | | | | 54.25 | 576.14 | | | |
| Malta | 657.40 | | | | 28.29 | 629.11 | | | | 630.39 | | | | 54.25 | 576.14 | | | |
| LI-241 | -13.05 | -21.49 | -28.51 | -36.54 | 29.68 | -42.73 | -51.17 | -58.19 | -66.22 | -13.05 | -21.49 | -28.51 | -36.54 | 55.64 | -68.70 | -77.14 | -84.15 | -92.19 |
| BL-131 | -21.02 | -39.50 | -55.01 | -72.56 | 29.68 | -50.70 | -69.18 | -84.69 | -102.24 | -21.02 | -39.50 | -55.01 | -72.56 | 55.64 | -76.66 | -95.14 | -110.65 | -128.21 |
| BL-171 | -7.17 | -22.15 | -34.89 | -49.08 | 29.68 | -36.85 | -51.83 | -64.57 | -78.77 | -7.17 | -22.15 | -34.89 | -49.08 | 55.64 | -62.82 | -77.80 | -90.53 | -104.73 |
| BL-181 (a) | 78.50 | 32.01 | -9.49 | -55.60 | 29.68 | 48.82 | 2.33 | -39.17 | -85.28 | 78.50 | 32.01 | -9.49 | -55.60 | 55.64 | 22.85 | -23.63 | -65.13 | -111.24 |
| VA-71 | 8.52 | -11.90 | -29.28 | -48.99 | 29.68 | -21.16 | -41.58 | -58.96 | -78.68 | -7.26 | -27.67 | -45.05 | -64.77 | 55.64 | -62.90 | -83.31 | -100.70 | -120.41 |
| VA-171 | 37.51 | 21.24 | 7.77 | -7.73 | 29.68 | 7.83 | -8.44 | -21.91 | -37.41 | 16.12 | -0.15 | -13.62 | -29.12 | 55.64 | -39.52 | -55.79 | -69.26 | -84.76 |
| VA-211 | 11.15 | -10.18 | -28.20 | -48.43 | 29.68 | -18.53 | -39.86 | -57.88 | -78.11 | 0.37 | -20.96 | -38.98 | -59.21 | 55.64 | -55.27 | -76.60 | -94.62 | -114.85 |
| VA-261 | 32.35 | 11.15 | -6.78 | -26.94 | 29.68 | 2.67 | -18.54 | -36.46 | -56.62 | 20.87 | -0.33 | -18.26 | -38.42 | 55.64 | -34.77 | -55.98 | -73.91 | -94.06 |
| VA-291 | 8.46 | -8.06 | -22.33 | -38.52 | 29.68 | -21.22 | -37.75 | -52.01 | -68.21 | -10.20 | -26.72 | -40.99 | -57.18 | 55.64 | -65.84 | -82.37 | -96.63 | -112.83 |
| VA-521 | 37.62 | 16.39 | -1.57 | -21.77 | 29.68 | 7.93 | -13.29 | -31.25 | -51.45 | 25.61 | 4.38 | -13.58 | -33.78 | 55.64 | -30.04 | -51.26 | -69.23 | -89.42 |
| **Little Missouri** | | | | | | | | | | | | | | | | | | |
| **Little Missouri River** | | | | | | | | | | | | | | | | | | |
| CT-011 | 20.48 | 9.17 | -0.74 | -11.69 | 29.68 | -9.21 | -20.51 | -30.42 | -41.37 | 0.18 | -11.13 | -21.04 | -31.99 | 55.64 | -55.47 | -66.77 | -76.69 | -87.64 |
| CT-012WS | 6.76 | -8.48 | -18.74 | -33.16 | 29.68 | -22.92 | -38.16 | -48.42 | -62.84 | 6.76 | -8.48 | -18.74 | -33.16 | 55.64 | -48.88 | -64.12 | -74.38 | -88.80 |
| CT-131 | 33.73 | 22.59 | 12.84 | 2.06 | 29.68 | 4.05 | -7.09 | -16.84 | -27.62 | 16.26 | 5.12 | -4.64 | -15.42 | 55.64 | -39.38 | -50.53 | -60.28 | -71.06 |
| CT-141WS | 32.47 | 18.24 | 6.01 | -8.99 | 29.68 | 2.79 | -11.44 | -23.67 | -38.68 | 32.47 | 18.24 | 6.01 | -8.99 | 55.64 | -23.17 | -37.41 | -49.63 | -64.64 |
| CT-161WS | 33.94 | 18.99 | 6.15 | -9.60 | 29.68 | 4.26 | -10.69 | -23.53 | -39.28 | 33.94 | 18.99 | 6.15 | -9.60 | 55.64 | -21.70 | -36.65 | -49.49 | -65.24 |
| CT-162WS | 32.73 | 18.31 | 5.93 | -9.26 | 29.68 | 3.04 | -11.37 | -23.75 | -38.94 | 32.73 | 18.31 | 5.93 | -9.26 | 55.64 | -22.92 | -37.33 | -49.71 | -64.90 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CT-181WS | 21.53 | 6.62 | -3.42 | -17.53 | 29.68 | -8.15 | -23.06 | -33.11 | -47.22 | 21.53 | 6.62 | -3.42 | -17.53 | 55.64 | -34.11 | -49.02 | -59.07 | -73.18 |
| CT-191 | 2.27 | -6.61 | -13.87 | -22.01 | 29.68 | -27.42 | -36.29 | -43.56 | -51.70 | -13.70 | -22.58 | -29.84 | -37.98 | 55.64 | -69.34 | -78.22 | -85.48 | -93.62 |
| CT-241 | 19.69 | 7.32 | -3.45 | -15.56 | 29.68 | -9.99 | -22.36 | -33.13 | -45.24 | 3.81 | -8.56 | -19.32 | -31.44 | 55.64 | -51.83 | -64.20 | -74.97 | -87.08 |
| CT-243WS | 32.69 | 18.28 | 5.90 | -9.30 | 29.68 | 3.01 | -11.40 | -23.79 | -38.98 | 32.69 | 18.28 | 5.90 | -9.30 | 55.64 | -22.96 | -37.37 | -49.75 | -64.94 |
| CT-244WS | 33.33 | 18.71 | 6.15 | -9.27 | 29.68 | 3.64 | -10.98 | -23.54 | -38.95 | 33.33 | 18.71 | 6.15 | -9.27 | 55.64 | -22.32 | -36.94 | -49.50 | -64.91 |
| **Boxelder Creek** | | | | | | | | | | | | | | | | | | |
| CT-121 | 6.28 | -5.24 | -14.62 | -25.46 | 29.68 | -23.40 | -34.92 | -44.30 | -55.14 | 6.28 | -5.24 | -14.62 | -25.46 | 55.64 | -49.36 | -60.89 | -70.26 | -81.10 |
| CT-122WS | 9.02 | -4.70 | -16.49 | -30.96 | 29.68 | -20.66 | -34.38 | -46.18 | -60.64 | 9.02 | -4.70 | -16.49 | -30.96 | 55.64 | -46.62 | -60.35 | -72.14 | -86.60 |
| CT-151WS | 31.25 | 17.42 | 5.53 | -9.05 | 29.68 | 1.57 | -12.26 | -24.15 | -38.73 | 31.25 | 17.42 | 5.53 | -9.05 | 55.64 | -24.39 | -38.23 | -50.11 | -64.70 |
| CT-152WS | 29.74 | 16.53 | 5.18 | -8.75 | 29.68 | 0.06 | -13.15 | -24.50 | -38.43 | 29.74 | 16.53 | 5.18 | -8.75 | 55.64 | -25.91 | -39.12 | -50.46 | -64.39 |
| CT-153WS | 30.22 | 16.77 | 5.22 | -8.96 | 29.68 | 0.54 | -12.91 | -24.47 | -38.64 | 30.22 | 16.77 | 5.22 | -8.96 | 55.64 | -25.42 | -38.87 | -50.43 | -64.61 |
| CT-154WS | 32.49 | 18.08 | 5.69 | -9.50 | 29.68 | 2.80 | -11.61 | -23.99 | -39.18 | 32.49 | 18.08 | 5.69 | -9.50 | 55.64 | -23.16 | -37.57 | -49.95 | -65.14 |
| CT-171WS | 18.88 | 4.35 | -5.44 | -19.19 | 29.68 | -10.80 | -25.33 | -35.12 | -48.87 | 18.88 | 4.35 | -5.44 | -19.19 | 55.64 | -36.76 | -51.29 | -61.08 | -74.84 |
| CT-221 | 18.86 | 6.12 | -5.29 | -17.57 | 29.68 | -10.82 | -23.56 | -34.97 | -47.25 | -0.62 | -13.36 | -24.77 | -37.05 | 55.64 | -56.27 | -69.00 | -80.41 | -92.70 |
| CT-251 | 23.34 | 11.07 | 0.36 | -11.49 | 29.68 | -6.35 | -18.61 | -29.32 | -41.17 | 3.24 | -9.02 | -19.74 | -31.58 | 55.64 | -52.40 | -64.67 | -75.38 | -87.23 |
| CT-261WS | 31.65 | 17.78 | 5.85 | -8.78 | 29.68 | 1.97 | -11.91 | -23.83 | -38.46 | 31.65 | 17.78 | 5.85 | -8.78 | 55.64 | -23.99 | -37.87 | -49.79 | -64.42 |
| CT-262WS | 43.83 | 24.61 | 8.10 | -12.15 | 29.68 | 14.14 | -5.07 | -21.58 | -41.83 | 43.83 | 24.61 | 8.10 | -12.15 | 55.64 | -11.82 | -31.03 | -47.54 | -67.79 |
| CT-310WS | 31.59 | 17.86 | 6.07 | -8.40 | 29.68 | 1.91 | -11.82 | -23.61 | -38.08 | 31.59 | 17.86 | 6.07 | -8.40 | 55.64 | -24.06 | -37.78 | -49.57 | -64.04 |
| CT-320 | -4.97 | -24.17 | -40.29 | -58.64 | 29.68 | -34.66 | -53.85 | -69.97 | -88.32 | -10.32 | -29.51 | -45.63 | -63.99 | 55.64 | -65.96 | -85.15 | -101.28 | -119.63 |
| CT-330 | 34.88 | 23.13 | 13.16 | 1.95 | 29.68 | 5.20 | -6.55 | -16.52 | -27.73 | 34.88 | 23.13 | 13.16 | 1.95 | 55.64 | -20.77 | -32.51 | -42.49 | -53.69 |
| CT-370 | 16.02 | 3.44 | -7.86 | -20.03 | 29.68 | -13.66 | -26.24 | -37.54 | -49.71 | 16.02 | 3.44 | -7.86 | -20.03 | 55.64 | -39.62 | -52.20 | -63.50 | -75.67 |
| CT-380 | -5.27 | -16.68 | -26.54 | -37.49 | 29.68 | -34.95 | -46.36 | -56.22 | -67.17 | -5.27 | -16.68 | -26.54 | -37.49 | 55.64 | -60.91 | -72.32 | -82.19 | -93.13 |
| **Little Beaver Creek** | | | | | | | | | | | | | | | | | | |
| Ekalaka | 657.40 | | | | 28.29 | 629.11 | | | | 630.39 | | | | 54.25 | 576.14 | | | |
| LB-061WS | 29.94 | 16.53 | 5.01 | -9.12 | 29.68 | 0.25 | -13.15 | -24.67 | -38.80 | 29.94 | 16.53 | 5.01 | -9.12 | 55.64 | -25.71 | -39.11 | -50.63 | -64.76 |
| LB-063WS | 32.18 | 17.77 | 5.39 | -9.80 | 29.68 | 2.50 | -11.91 | -24.29 | -39.48 | 32.18 | 17.77 | 5.39 | -9.80 | 55.64 | -23.46 | -37.87 | -50.25 | -65.45 |
| LB-083WS | 29.31 | 15.97 | 4.50 | -9.56 | 29.68 | -0.37 | -13.71 | -25.18 | -39.24 | 29.31 | 15.97 | 4.50 | -9.56 | 55.64 | -26.33 | -39.68 | -51.14 | -65.21 |
| LB-141WS | 17.63 | 3.22 | -6.49 | -20.13 | 29.68 | -12.05 | -26.46 | -36.17 | -49.81 | 17.63 | 3.22 | -6.49 | -20.13 | 55.64 | -38.01 | -52.42 | -62.13 | -75.78 |
| LB-151WS | 27.46 | 13.93 | 2.32 | -11.94 | 29.68 | -2.23 | -15.75 | -27.36 | -41.62 | 27.46 | 13.93 | 2.32 | -11.94 | 55.64 | -28.19 | -41.71 | -53.33 | -67.58 |
| LB-181WS | 26.76 | 15.02 | 4.93 | -7.45 | 29.68 | -2.92 | -14.66 | -24.75 | -37.13 | 26.76 | 15.02 | 4.93 | -7.45 | 55.64 | -28.88 | -40.62 | -50.71 | -63.09 |
| LB-182WS | 27.12 | 15.11 | 4.80 | -7.86 | 29.68 | -2.56 | -14.57 | -24.88 | -37.54 | 27.12 | 15.11 | 4.80 | -7.86 | 55.64 | -28.52 | -40.53 | -50.85 | -63.50 |
| CT-041WS | 16.96 | 3.23 | -6.03 | -19.03 | 29.68 | -12.72 | -26.45 | -35.71 | -48.71 | 16.96 | 3.23 | -6.03 | -19.03 | 55.64 | -38.68 | -52.42 | -61.67 | -74.67 |
| CT-071 | 59.66 | 40.29 | 23.90 | 5.07 | 29.68 | 29.98 | 10.61 | -5.78 | -24.62 | 59.66 | 40.29 | 23.90 | 5.07 | 55.64 | 4.02 | -15.35 | -31.74 | -50.58 |
| CT-291WS | 30.39 | 16.66 | 4.87 | -9.60 | 29.68 | 0.71 | -13.02 | -24.81 | -39.28 | 30.39 | 16.66 | 4.87 | -9.60 | 55.64 | -25.26 | -38.98 | -50.77 | -65.24 |
| CT-293WS | 35.00 | 18.99 | 5.24 | -11.64 | 29.68 | 5.32 | -10.69 | -24.45 | -41.33 | 35.00 | 18.99 | 5.24 | -11.64 | 55.64 | -20.64 | -36.65 | -50.41 | -67.29 |
| CT-294 | -14.88 | -33.69 | -49.63 | -67.86 | 29.68 | -44.56 | -63.37 | -79.31 | -97.55 | -29.50 | -48.31 | -64.25 | -82.49 | 55.64 | -85.15 | -103.95 | -119.89 | -138.13 |
| CT-301WS | -4.79 | -18.90 | -28.40 | -41.76 | 29.68 | -34.47 | -48.58 | -58.09 | -71.44 | -4.79 | -18.90 | -28.40 | -41.76 | 55.64 | -60.43 | -74.54 | -84.05 | -97.40 |
| CT-340WS | 18.51 | 3.71 | -6.27 | -20.27 | 29.68 | -11.17 | -25.98 | -35.95 | -49.96 | 18.51 | 3.71 | -6.27 | -20.27 | 55.64 | -37.14 | -51.94 | -61.91 | -75.92 |
| **Beaver Creek** | | | | | | | | | | | | | | | | | | |
| Wibaux | 657.40 | | | | 28.29 | 629.11 | | | | 630.39 | | | | 54.25 | 576.14 | | | |
| WI-41WS | 7.46 | -3.89 | -13.65 | -25.61 | 29.68 | -22.22 | -33.57 | -43.33 | -55.30 | 7.46 | -3.89 | -13.65 | -25.61 | 55.64 | -48.18 | -59.53 | -69.29 | -81.26 |
| WI-42WS | -2.92 | -14.99 | -23.12 | -34.55 | 29.68 | -32.60 | -44.67 | -52.80 | -64.23 | -2.92 | -14.99 | -23.12 | -34.55 | 55.64 | -58.56 | -70.63 | -78.77 | -90.19 |
| WI-43WS | 25.52 | 14.05 | 4.20 | -7.89 | 29.68 | -4.16 | -15.63 | -25.48 | -37.57 | 25.52 | 14.05 | 4.20 | -7.89 | 55.64 | -30.13 | -41.59 | -51.44 | -63.53 |
| WI-61WS | 16.21 | 4.68 | -5.23 | -17.38 | 29.68 | -13.48 | -25.00 | -34.91 | -47.06 | 16.21 | 4.68 | -5.23 | -17.38 | 55.64 | -39.44 | -50.97 | -60.87 | -73.02 |
| WI-71WS | 24.49 | 13.28 | 3.65 | -8.17 | 29.68 | -5.20 | -16.40 | -26.03 | -37.85 | 24.49 | 13.28 | 3.65 | -8.17 | 55.64 | -31.16 | -42.37 | -52.00 | -63.81 |
| WI-72WS | 23.99 | 13.01 | 3.57 | -8.00 | 29.68 | -5.70 | -16.68 | -26.11 | -37.68 | 23.99 | 13.01 | 3.57 | -8.00 | 55.64 | -31.66 | -42.64 | -52.07 | -63.64 |
| WI-73WS | -3.96 | -15.64 | -23.50 | -34.55 | 29.68 | -33.64 | -45.32 | -53.18 | -64.23 | -3.96 | -15.64 | -23.50 | -34.55 | 55.64 | -59.61 | -71.28 | -79.14 | -90.19 |
| WI-74WS | 10.75 | -0.45 | -10.08 | -21.90 | 29.68 | -18.93 | -30.14 | -39.77 | -51.58 | 10.75 | -0.45 | -10.08 | -21.90 | 55.64 | -44.89 | -56.10 | -65.73 | -77.54 |
| WI-75WS | 10.04 | -1.11 | -10.68 | -22.43 | 29.68 | -19.64 | -30.79 | -40.36 | -52.11 | 10.04 | -1.11 | -10.68 | -22.43 | 55.64 | -45.61 | -56.75 | -66.32 | -78.07 |
| WI-91WS | 6.71 | -4.73 | -14.56 | -26.61 | 29.68 | -22.97 | -34.41 | -44.24 | -56.29 | 6.71 | -4.73 | -14.56 | -26.61 | 55.64 | -48.94 | -60.37 | -70.20 | -82.26 |
| WI-92WS | 10.00 | -1.10 | -10.64 | -22.35 | 29.68 | -19.68 | -30.79 | -40.32 | -52.03 | 10.00 | -1.10 | -10.64 | -22.35 | 55.64 | -45.65 | -56.75 | -66.29 | -77.99 |
| WI-93WS | 25.80 | 14.27 | 4.36 | -7.79 | 29.68 | -3.88 | -15.41 | -25.32 | -37.47 | 25.80 | 14.27 | 4.36 | -7.79 | 55.64 | -29.84 | -41.37 | -51.28 | -63.43 |
| WI-121WS | 24.62 | 13.34 | 3.65 | -8.24 | 29.68 | -5.06 | -16.34 | -26.03 | -37.92 | 24.62 | 13.34 | 3.65 | -8.24 | 55.64 | -31.03 | -42.30 | -51.99 | -63.88 |
| WI-151WS | 16.72 | 5.58 | -3.99 | -15.73 | 29.68 | -12.96 | -24.10 | -33.67 | -45.41 | 16.72 | 5.58 | -3.99 | -15.73 | 55.64 | -38.93 | -50.06 | -59.63 | -71.38 |
| WI-161WS | 7.31 | -3.81 | -13.37 | -25.10 | 29.68 | -22.37 | -33.49 | -43.05 | -54.78 | 7.31 | -3.81 | -13.37 | -25.10 | 55.64 | -48.33 | -59.45 | -69.01 | -80.74 |
| WI-162WS | 7.58 | -3.95 | -13.85 | -26.01 | 29.68 | -22.10 | -33.63 | -43.54 | -55.69 | 7.58 | -3.95 | -13.85 | -26.01 | 55.64 | -48.06 | -59.59 | -69.50 | -81.65 |
| WI-171WS | 9.57 | -1.87 | -11.69 | -23.75 | 29.68 | -20.11 | -31.55 | -41.37 | -53.43 | 9.57 | -1.87 | -11.69 | -23.75 | 55.64 | -46.07 | -57.51 | -67.33 | -79.39 |
| WI-181WS | 7.43 | -3.87 | -13.58 | -25.50 | 29.68 | -22.25 | -33.55 | -43.26 | -55.18 | 7.43 | -3.87 | -13.58 | -25.50 | 55.64 | -48.21 | -59.52 | -69.23 | -81.14 |
| WI-191WS | 13.10 | 1.66 | -8.16 | -20.22 | 29.68 | -16.58 | -28.02 | -37.84 | -49.90 | 13.10 | 1.66 | -8.16 | -20.22 | 55.64 | -42.54 | -53.98 | -63.81 | -75.86 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WI-192WS | 7.89 | -4.11 | -14.43 | -27.09 | 29.68 | -21.79 | -33.80 | -44.11 | -56.77 | 7.89 | -4.11 | -14.43 | -27.09 | 55.64 | -47.75 | -59.76 | -70.08 | -82.73 |
| WI-201WS | 19.04 | 7.91 | -1.65 | -13.39 | 29.68 | -10.64 | -21.77 | -31.34 | -43.07 | 19.04 | 7.91 | -1.65 | -13.39 | 55.64 | -36.60 | -47.73 | -57.30 | -69.03 |
| WI-202WS | 24.08 | 12.96 | 3.40 | -8.33 | 29.68 | -5.60 | -16.72 | -26.28 | -38.01 | 24.08 | 12.96 | 3.40 | -8.33 | 55.64 | -31.56 | -42.69 | -52.24 | -63.97 |
| WI-211WS | 24.92 | 13.77 | 4.20 | -7.55 | 29.68 | -4.77 | -15.91 | -25.49 | -37.23 | 24.92 | 13.77 | 4.20 | -7.55 | 55.64 | -30.73 | -41.87 | -51.45 | -63.19 |
| WI-221WS | 7.37 | -3.84 | -13.47 | -25.29 | 29.68 | -22.31 | -33.52 | -43.15 | -54.97 | 7.37 | -3.84 | -13.47 | -25.29 | 55.64 | -48.27 | -59.48 | -69.11 | -80.93 |
| WI-232WS | 17.23 | 6.02 | -3.61 | -15.42 | 29.68 | -12.45 | -23.66 | -33.29 | -45.10 | 17.23 | 6.02 | -3.61 | -15.42 | 55.64 | -38.41 | -49.62 | -59.25 | -71.06 |
| WI-233WS | 26.21 | 14.04 | 3.58 | -9.25 | 29.68 | -3.48 | -15.64 | -26.10 | -38.93 | 26.21 | 14.04 | 3.58 | -9.25 | 55.64 | -29.44 | -41.61 | -52.06 | -64.89 |
| WI-234WS | 24.46 | 13.31 | 3.73 | -8.02 | 29.68 | -5.22 | -16.37 | -25.95 | -37.70 | 24.46 | 13.31 | 3.73 | -8.02 | 55.64 | -31.18 | -42.33 | -51.91 | -63.67 |
| WI-235WS | SAME AS WI-191 | | | | | | | | | | | | | | | | | |
| WI-236WS | 9.68 | -1.67 | -11.42 | -23.39 | 29.68 | -20.00 | -31.35 | -41.11 | -53.07 | 9.68 | -1.67 | -11.42 | -23.39 | 55.64 | -45.96 | -57.31 | -67.07 | -79.04 |
| WI-237WS | 7.49 | -3.90 | -13.68 | -25.69 | 29.68 | -22.20 | -33.58 | -43.37 | -55.37 | 7.49 | -3.90 | -13.68 | -25.69 | 55.64 | -48.16 | -59.54 | -69.33 | -81.33 |
| LB-011WS | 17.28 | 2.77 | -9.69 | -24.98 | 29.68 | -12.41 | -26.91 | -39.37 | -54.66 | 17.28 | 2.77 | -9.69 | -24.98 | 55.64 | -38.37 | -52.87 | -65.33 | -80.63 |
| LB-041WS | 24.42 | 12.59 | 2.43 | -10.03 | 29.68 | -5.26 | -17.09 | -27.25 | -39.71 | 24.42 | 12.59 | 2.43 | -10.03 | 55.64 | -31.23 | -43.05 | -53.21 | -65.67 |
| LB-121WS | 10.25 | -2.34 | -13.16 | -26.44 | 29.68 | -19.43 | -32.02 | -42.84 | -56.12 | 10.25 | -2.34 | -13.16 | -26.44 | 55.64 | -45.39 | -57.99 | -68.80 | -82.08 |
| LB-161WS | 9.47 | -3.72 | -12.61 | -25.09 | 29.68 | -20.21 | -33.40 | -42.29 | -54.77 | 9.47 | -3.72 | -12.61 | -25.09 | 55.64 | -46.17 | -59.36 | -68.25 | -80.74 |
| LB-171WS | 11.02 | -1.51 | -12.28 | -25.49 | 29.68 | -18.66 | -31.19 | -41.96 | -55.17 | 11.02 | -1.51 | -12.28 | -25.49 | 55.64 | -44.62 | -57.16 | -67.92 | -81.13 |
| LB-172WS | 25.48 | 12.67 | 1.66 | -11.84 | 29.68 | -4.20 | -17.01 | -28.02 | -41.52 | 25.48 | 12.67 | 1.66 | -11.84 | 55.64 | -30.16 | -42.97 | -53.98 | -67.48 |
| LB-191WS | 1.03 | -11.51 | -19.97 | -31.85 | 29.68 | -28.65 | -41.20 | -49.65 | -61.53 | 1.03 | -11.51 | -19.97 | -31.85 | 55.64 | -54.61 | -67.16 | -75.61 | -87.49 |

(a) BL-181 is not a financially or economically feasible project. Although the the consumptive water value for BL-181 is positive in 10 and 8 years out of 10 years.

(b) The consumptive value of water given it is available X years out of 10.

(c) The net value of water given it is available X years out of 10.

Table L-2. Comparison of water values for consumptive use and instream use ($/acft)

| Subbasin Drainage Project | 50 MILL (5 CENTS) PER KILOWATT HOUR REPLACEMENT COST | | | | | | | | | 100 MILL (10 CENTS) PER KILOWATT HOUR REPLACEMENT COST | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CONSUMPTIVE VALUE | | | | INSTREAM | CONSUMPTIVE VALUE MINUS INSTREAM VALUE | | | | CONSUMPTIVE VALUE | | | | INSTREAM | CONSUMPTIVE VALUE MINUS INSTREAM VALUE | | | |
| | 10/10 | 8/10 | 6/10 | 4/10 | VALUE | 10/10 | 8/10 | 6/10 | 4/10 | 10/10 | 8/10 | 6/10 | 4/10 | VALUE | 10/10 | 8/10 | 6/10 | 4/10 |
| **Sheridan County Groundwater Area** | | | | | | | | | | | | | | | | | | |
| Plentywood | 657.40 | | | | 28.29 | 629.11 | | | | 630.39 | | | | 54.25 | 576.14 | | | |
| 2.1 | 5.59 | -2.88 | -9.96 | -18.13 | 3.72 | 1.87 | -6.60 | -13.68 | -21.85 | -47.16 | -55.62 | -62.71 | -70.88 | 3.72 | -50.88 | -59.34 | -66.43 | -74.60 |
| 3.1 | 7.75 | -0.87 | -8.11 | -16.45 | 3.72 | 4.03 | -4.59 | -11.83 | -20.17 | -36.71 | -45.33 | -52.58 | -60.91 | 3.72 | -40.43 | -49.05 | -56.30 | -64.63 |
| 4.1 | 9.50 | 0.79 | -6.58 | -15.04 | 3.72 | 5.78 | -2.93 | -10.30 | -18.76 | -31.27 | -39.98 | -47.34 | -55.80 | 3.72 | -34.99 | -43.70 | -51.06 | -59.52 |
| 4.2 | -26.38 | -33.36 | -39.74 | -46.48 | 3.72 | -30.10 | -37.08 | -43.46 | -50.20 | -154.84 | -161.82 | -168.20 | -174.94 | 3.72 | -158.56 | -165.54 | -171.92 | -178.66 |
| 6.1 | 6.16 | -2.31 | -9.40 | -17.56 | 3.72 | 2.44 | -6.03 | -13.12 | -21.28 | -43.85 | -52.32 | -59.41 | -67.57 | 3.72 | -47.57 | -56.04 | -63.13 | -71.29 |
| 8.1 | 7.75 | -0.87 | -8.11 | -16.45 | 3.72 | 4.03 | -4.59 | -11.83 | -20.17 | -36.71 | -45.33 | -52.57 | -60.91 | 3.72 | -40.43 | -49.05 | -56.29 | -64.63 |
| 9.1 | -26.96 | -33.87 | -40.13 | -46.85 | 3.72 | -30.68 | -37.59 | -43.85 | -50.57 | -154.60 | -161.50 | -167.76 | -174.48 | 3.72 | -158.32 | -165.22 | -171.48 | -178.20 |
| 9.2 | 6.14 | -2.33 | -9.42 | -17.58 | 3.72 | 2.42 | -6.05 | -13.14 | -21.30 | -43.87 | -52.34 | -59.43 | -67.59 | 3.72 | -47.59 | -56.06 | -63.15 | -71.31 |
| 10.1 | 6.14 | -2.33 | -9.42 | -17.58 | 3.72 | 2.42 | -6.05 | -13.14 | -21.30 | -43.87 | -52.34 | -59.43 | -67.59 | 3.72 | -47.59 | -56.06 | -63.15 | -71.31 |
| 10.2 | 7.79 | -0.83 | -8.07 | -16.41 | 3.72 | 4.07 | -4.55 | -11.79 | -20.13 | -36.67 | -45.29 | -52.54 | -60.87 | 3.72 | -40.39 | -49.01 | -56.26 | -64.59 |
| 11.1 | -19.75 | -26.79 | -33.27 | -40.08 | 3.72 | -23.47 | -30.51 | -36.99 | -43.80 | -132.31 | -139.36 | -145.83 | -152.65 | 3.72 | -136.03 | -143.08 | -149.55 | -156.37 |
| 11.2 | -4.88 | -12.11 | -18.59 | -25.40 | 3.72 | -8.60 | -15.83 | -22.31 | -29.12 | -59.88 | -67.12 | -73.59 | -80.40 | 3.72 | -63.60 | -70.84 | -77.31 | -84.12 |
| 11.3 | -8.38 | -15.42 | -21.89 | -28.70 | 3.72 | -12.10 | -19.14 | -25.61 | -32.42 | -75.26 | -82.30 | -88.77 | -95.58 | 3.72 | -78.98 | -86.02 | -92.49 | -99.30 |
| 11.4 | 11.18 | 2.41 | -5.04 | -13.62 | 3.72 | 7.46 | -1.31 | -8.76 | -17.34 | -19.87 | -28.64 | -36.09 | -44.67 | 3.72 | -23.59 | -32.36 | -39.81 | -48.39 |
| 11.5 | -24.68 | -31.71 | -38.17 | -44.97 | 3.72 | -28.40 | -35.43 | -41.89 | -48.69 | -142.38 | -149.41 | -155.87 | -162.67 | 3.72 | -146.10 | -153.13 | -159.59 | -166.39 |
| 11.6 | 8.69 | -0.06 | -7.50 | -16.07 | 3.72 | 4.97 | -3.78 | -11.22 | -19.79 | -34.25 | -43.00 | -50.44 | -59.01 | 3.72 | -37.97 | -46.72 | -54.16 | -62.73 |
| 14.1 | 6.17 | -2.44 | -9.68 | -18.02 | 3.72 | 2.45 | -6.16 | -13.40 | -21.74 | -46.88 | -55.49 | -62.73 | -71.07 | 3.72 | -50.60 | -59.21 | -66.45 | -74.79 |
| 14.2 | 6.11 | -2.50 | -9.75 | -18.08 | 3.72 | 2.39 | -6.22 | -13.47 | -21.80 | -46.55 | -55.16 | -62.40 | -70.74 | 3.72 | -50.27 | -58.88 | -66.12 | -74.46 |
| 14.3 | -14.99 | -22.02 | -28.48 | -35.27 | 3.72 | -18.71 | -25.74 | -32.20 | -38.99 | -90.61 | -97.64 | -104.10 | -110.89 | 3.72 | -94.33 | -101.36 | -107.82 | -114.61 |
| 14.4 | -14.77 | -21.80 | -28.26 | -35.05 | 3.72 | -18.49 | -25.52 | -31.98 | -38.77 | -90.39 | -97.42 | -103.88 | -110.67 | 3.72 | -94.11 | -101.14 | -107.60 | -114.39 |
| 14.5 | -9.66 | -16.57 | -22.84 | -29.57 | 3.72 | -13.38 | -20.29 | -26.56 | -33.29 | -69.30 | -76.22 | -82.49 | -89.21 | 3.72 | -73.02 | -79.94 | -86.21 | -92.93 |
| 14.6 | -29.36 | -36.28 | -42.56 | -49.30 | 3.72 | -33.08 | -40.00 | -46.28 | -53.02 | -197.33 | -204.25 | -210.53 | -217.26 | 3.72 | -201.05 | -207.97 | -214.25 | -220.98 |
| 14.7 | 7.98 | -0.64 | -7.89 | -16.23 | 3.72 | 4.26 | -4.36 | -11.61 | -19.95 | -36.49 | -45.11 | -52.35 | -60.69 | 3.72 | -40.21 | -48.83 | -56.07 | -64.41 |
| 14.8 | 8.06 | -0.56 | -7.80 | -16.14 | 3.72 | 4.34 | -4.28 | -11.52 | -19.86 | -36.40 | -45.02 | -52.26 | -60.60 | 3.72 | -40.12 | -48.74 | -55.98 | -64.32 |
| 14.9 | 9.02 | 0.40 | -6.84 | -15.17 | 3.72 | 5.30 | -3.32 | -10.56 | -18.89 | -33.76 | -42.37 | -49.61 | -57.95 | 3.72 | -37.48 | -46.09 | -53.33 | -61.67 |
| 15.1 | 6.08 | -2.39 | -9.47 | -17.64 | 3.72 | 2.36 | -6.11 | -13.19 | -21.36 | -43.93 | -52.40 | -59.48 | -67.65 | 3.72 | -47.65 | -56.12 | -63.20 | -71.37 |
| 15.2 | 5.73 | -2.73 | -9.83 | -18.00 | 3.72 | 2.01 | -6.45 | -13.55 | -21.72 | -46.33 | -54.80 | -61.89 | -70.06 | 3.72 | -50.05 | -58.52 | -65.61 | -73.78 |
| 15.3 | 6.18 | -2.29 | -9.38 | -17.55 | 3.72 | 2.46 | -6.01 | -13.10 | -21.27 | -43.84 | -52.30 | -59.39 | -67.56 | 3.72 | -47.56 | -56.02 | -63.11 | -71.28 |
| 17.1 | -24.10 | -31.01 | -37.28 | -44.02 | 3.72 | -27.82 | -34.73 | -41.00 | -47.74 | -146.16 | -153.08 | -159.35 | -166.08 | 3.72 | -149.88 | -156.80 | -163.07 | -169.80 |
| 17.2 | -28.41 | -35.33 | -41.59 | -48.32 | 3.72 | -32.13 | -39.05 | -45.31 | -52.04 | -162.57 | -169.48 | -175.75 | -182.48 | 3.72 | -166.29 | -173.20 | -179.47 | -186.20 |
| 18.1 | 7.75 | -0.87 | -8.12 | -16.45 | 3.72 | 4.03 | -4.59 | -11.84 | -20.17 | -36.72 | -45.34 | -52.58 | -60.92 | 3.72 | -40.44 | -49.06 | -56.30 | -64.64 |
| 18.2 | 7.71 | -0.91 | -8.15 | -16.49 | 3.72 | 3.99 | -4.63 | -11.87 | -20.21 | -36.75 | -45.37 | -52.61 | -60.95 | 3.72 | -40.47 | -49.09 | -56.33 | -64.67 |
| 19.1 | 6.09 | -2.37 | -9.46 | -17.63 | 3.72 | 2.37 | -6.09 | -13.18 | -21.35 | -43.92 | -52.38 | -59.47 | -67.64 | 3.72 | -47.64 | -56.10 | -63.19 | -71.36 |
| 19.2 | -50.84 | -59.47 | -66.73 | -75.08 | 3.72 | -54.56 | -63.19 | -70.45 | -78.80 | -386.77 | -395.40 | -402.66 | -411.01 | 3.72 | -390.49 | -399.12 | -406.38 | -414.73 |
| 20.1 | -17.54 | -24.45 | -30.71 | -37.43 | 3.72 | -21.26 | -28.17 | -34.43 | -41.15 | -116.81 | -123.72 | -129.98 | -136.70 | 3.72 | -120.53 | -127.44 | -133.70 | -140.42 |
| 20.2 | -11.77 | -18.88 | -25.15 | -31.88 | 3.72 | -15.49 | -22.60 | -28.87 | -35.60 | -97.82 | -104.93 | -111.20 | -117.93 | 3.72 | -101.54 | -108.65 | -114.92 | -121.65 |
| 20.3 | 8.52 | -0.10 | -7.35 | -15.70 | 3.72 | 4.80 | -3.82 | -11.07 | -19.42 | -33.01 | -41.64 | -48.89 | -57.23 | 3.72 | -36.73 | -45.36 | -52.61 | -60.95 |
| 21.1 | 8.04 | -0.57 | -7.81 | -16.15 | 3.72 | 4.32 | -4.29 | -11.53 | -19.87 | -34.73 | -43.35 | -50.59 | -58.92 | 3.72 | -38.45 | -47.07 | -54.31 | -62.64 |
| 21.2 | -22.14 | -29.06 | -35.33 | -42.06 | 3.72 | -25.86 | -32.78 | -39.05 | -45.78 | -144.21 | -151.12 | -157.40 | -164.13 | 3.72 | -147.93 | -154.84 | -161.12 | -167.85 |
| 21.3 | 7.96 | -0.66 | -7.90 | -16.23 | 3.72 | 4.24 | -4.38 | -11.62 | -19.95 | -34.82 | -43.44 | -50.68 | -59.01 | 3.72 | -38.54 | -47.16 | -54.40 | -62.73 |
| 22.1 | 6.21 | -2.26 | -9.35 | -17.51 | 3.72 | 2.49 | -5.98 | -13.07 | -21.23 | -43.80 | -52.27 | -59.36 | -67.52 | 3.72 | -47.52 | -55.99 | -63.08 | -71.24 |
| 22.2 | 6.31 | -2.16 | -9.25 | -17.42 | 3.72 | 2.59 | -5.88 | -12.97 | -21.14 | -43.71 | -52.17 | -59.26 | -67.43 | 3.72 | -47.43 | -55.89 | -62.98 | -71.15 |
| 22.5 | -INF | -INF | -INF | -INF | 3.72 | -INF | -INF | -INF | -INF | -INF | -INF | -INF | -INF | 3.72 | -INF | -INF | -INF | -INF |
| 23.1 | 8.80 | 0.18 | -7.07 | -15.41 | 3.72 | 5.08 | -3.54 | -10.79 | -19.13 | -31.49 | -40.11 | -47.35 | -55.69 | 3.72 | -35.21 | -43.83 | -51.07 | -59.41 |
| 23.2 | -21.08 | -27.98 | -34.25 | -40.98 | 3.72 | -24.80 | -31.70 | -37.97 | -44.70 | -118.28 | -125.19 | -131.45 | -138.18 | 3.72 | -122.00 | -128.91 | -135.17 | -141.90 |
| 23.3 | -35.23 | -42.15 | -48.43 | -55.17 | 3.72 | -38.95 | -45.87 | -52.15 | -58.89 | -203.20 | -210.12 | -216.40 | -223.13 | 3.72 | -206.92 | -213.84 | -220.12 | -226.85 |
| 23.4 | 7.81 | -0.80 | -8.05 | -16.39 | 3.72 | 4.09 | -4.52 | -11.77 | -20.11 | -36.65 | -45.27 | -52.51 | -60.85 | 3.72 | -40.37 | -48.99 | -56.23 | -64.57 |
| 23.5 | 8.99 | 0.37 | -6.87 | -15.20 | 3.72 | 5.27 | -3.35 | -10.59 | -18.92 | -29.91 | -38.52 | -45.76 | -54.10 | 3.72 | -33.63 | -42.24 | -49.48 | -57.82 |
| 26.1 | 5.85 | -2.61 | -9.70 | -17.87 | 3.72 | 2.13 | -6.33 | -13.42 | -21.59 | -44.16 | -52.62 | -59.71 | -67.88 | 3.72 | -47.88 | -56.34 | -63.43 | -71.60 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28.1 | 5.81 | -2.65 | -9.74 | -17.91 | 3.72 | 2.09 | -6.37 | -13.46 | -21.63 | -46.59 | -55.06 | -62.14 | -70.31 | 3.72 | -50.31 | -58.78 | -65.86 | -74.03 |
| 28.2 | 5.82 | -2.65 | -9.74 | -17.92 | 3.72 | 2.10 | -6.37 | -13.46 | -21.64 | -46.25 | -54.72 | -61.81 | -69.98 | 3.72 | -49.97 | -58.44 | -65.53 | -73.70 |
| 28.3 | 6.18 | -2.27 | -9.35 | -17.51 | 3.72 | 2.46 | -5.99 | -13.07 | -21.23 | -45.10 | -53.56 | -60.64 | -68.80 | 3.72 | -48.82 | -57.28 | -64.36 | -72.52 |
| 30.1 | -9.99 | -16.97 | -23.36 | -30.10 | 3.72 | -13.71 | -20.69 | -27.08 | -33.82 | -97.40 | -104.38 | -110.77 | -117.51 | 3.72 | -101.12 | -108.10 | -114.49 | -121.23 |
| 30.2 | 9.33 | 0.62 | -6.75 | -15.21 | 3.72 | 5.61 | -3.10 | -10.47 | -18.93 | -33.11 | -41.82 | -49.19 | -57.65 | 3.72 | -36.83 | -45.54 | -52.91 | -61.37 |
| 30.3 | 9.50 | 0.79 | -6.58 | -15.04 | 3.72 | 5.78 | -2.93 | -10.30 | -18.76 | -31.27 | -39.98 | -47.34 | -55.80 | 3.72 | -34.99 | -43.70 | -51.06 | -59.52 |
| 30.4 | 9.33 | 0.62 | -6.75 | -15.21 | 3.72 | 5.61 | -3.10 | -10.47 | -18.93 | -33.11 | -41.82 | -49.19 | -57.65 | 3.72 | -36.83 | -45.54 | -52.91 | -61.37 |
| 30.5 | 9.53 | 0.83 | -6.54 | -15.00 | 3.72 | 5.81 | -2.89 | -10.26 | -18.72 | -31.23 | -39.94 | -47.30 | -55.77 | 3.72 | -34.95 | -43.66 | -51.02 | -59.49 |
| 30.6 | 9.61 | 0.90 | -6.46 | -14.92 | 3.72 | 5.89 | -2.82 | -10.18 | -18.64 | -31.15 | -39.86 | -47.23 | -55.69 | 3.72 | -34.87 | -43.58 | -50.95 | -59.41 |
| 30.7 | 9.50 | 0.79 | -6.58 | -15.04 | 3.72 | 5.78 | -2.93 | -10.30 | -18.76 | -31.27 | -39.98 | -47.34 | -55.80 | 3.72 | -34.99 | -43.70 | -51.06 | -59.52 |
| 30.8 | 9.50 | 0.79 | -6.58 | -15.04 | 3.72 | 5.78 | -2.93 | -10.30 | -18.76 | -31.27 | -39.98 | -47.34 | -55.80 | 3.72 | -34.99 | -43.70 | -51.06 | -59.52 |
| 30.9 | 9.50 | 0.79 | -6.58 | -15.04 | 3.72 | 5.78 | -2.93 | -10.30 | -18.76 | -31.27 | -39.98 | -47.34 | -55.80 | 3.72 | -34.99 | -43.70 | -51.06 | -59.52 |
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| 32.1 | -19.56 | -26.36 | -32.44 | -39.05 | 3.72 | -23.28 | -30.08 | -36.16 | -42.77 | -108.71 | -115.52 | -121.59 | -128.21 | 3.72 | -112.43 | -119.24 | -125.31 | -131.93 |
| 32.2 | -19.52 | -26.32 | -32.40 | -39.01 | 3.72 | -23.24 | -30.04 | -36.12 | -42.73 | -108.67 | -115.47 | -121.55 | -128.16 | 3.72 | -112.39 | -119.19 | -125.27 | -131.88 |
| 32.3 | -39.91 | -46.71 | -52.78 | -59.39 | 3.72 | -43.63 | -50.43 | -56.50 | -63.11 | -229.97 | -236.77 | -242.85 | -249.46 | 3.72 | -233.69 | -240.49 | -246.57 | -253.18 |
| 33.1 | -12.12 | -18.93 | -25.01 | -31.62 | 3.72 | -15.84 | -22.65 | -28.73 | -35.34 | -101.28 | -108.08 | -114.16 | -120.77 | 3.72 | -105.00 | -111.80 | -117.88 | -124.49 |
| 34.1 | 5.89 | -2.57 | -9.66 | -17.83 | 3.72 | 2.17 | -6.29 | -13.38 | -21.55 | -44.12 | -52.58 | -59.67 | -67.84 | 3.72 | -47.84 | -56.30 | -63.39 | -71.56 |
| 34.2 | 6.14 | -2.33 | -9.42 | -17.58 | 3.72 | 2.42 | -6.05 | -13.14 | -21.30 | -43.87 | -52.34 | -59.43 | -67.59 | 3.72 | -47.59 | -56.06 | -63.15 | -71.31 |
| 34.3 | 6.49 | -1.98 | -9.07 | -17.23 | 3.72 | 2.77 | -5.70 | -12.79 | -20.95 | -43.52 | -51.99 | -59.08 | -67.24 | 3.72 | -47.24 | -55.71 | -62.80 | -70.96 |
| 35.1 | 7.71 | -0.91 | -8.15 | -16.49 | 3.72 | 3.99 | -4.63 | -11.87 | -20.21 | -36.75 | -45.37 | -52.61 | -60.95 | 3.72 | -40.47 | -49.09 | -56.33 | -64.67 |
| 36.1 | 6.18 | -2.29 | -9.38 | -17.54 | 3.72 | 2.46 | -6.01 | -13.10 | -21.26 | -43.83 | -52.30 | -59.39 | -67.56 | 3.72 | -47.55 | -56.02 | -63.11 | -71.28 |
| 37.1 | -20.70 | -27.51 | -33.59 | -40.21 | 3.72 | -24.42 | -31.23 | -37.31 | -43.93 | -112.80 | -119.60 | -125.69 | -132.30 | 3.72 | -116.52 | -123.32 | -129.41 | -136.02 |
| 38.1 | 7.75 | -0.87 | -8.12 | -16.45 | 3.72 | 4.03 | -4.59 | -11.84 | -20.17 | -36.72 | -45.34 | -52.58 | -60.92 | 3.72 | -40.44 | -49.06 | -56.30 | -64.64 |
| 38.2 | 7.75 | -0.87 | -8.11 | -16.45 | 3.72 | 4.03 | -4.59 | -11.83 | -20.17 | -36.71 | -45.33 | -52.57 | -60.91 | 3.72 | -40.43 | -49.05 | -56.29 | -64.63 |
| 38.3 | -20.01 | -26.92 | -33.19 | -39.92 | 3.72 | -23.73 | -30.64 | -36.91 | -43.64 | -111.30 | -118.21 | -124.48 | -131.21 | 3.72 | -115.02 | -121.93 | -128.20 | -134.93 |
| 39.1 | -34.40 | -41.32 | -47.60 | -54.34 | 3.72 | -38.12 | -45.04 | -51.32 | -58.06 | -202.37 | -209.29 | -215.56 | -222.30 | 3.72 | -206.09 | -213.01 | -219.28 | -226.02 |
| 39.2 | 6.14 | -2.33 | -9.42 | -17.58 | 3.72 | 2.42 | -6.05 | -13.14 | -21.30 | -43.87 | -52.34 | -59.43 | -67.59 | 3.72 | -47.59 | -56.06 | -63.15 | -71.31 |
| 39.3 | 5.73 | -2.73 | -9.83 | -18.00 | 3.72 | 2.01 | -6.45 | -13.55 | -21.72 | -46.33 | -54.80 | -61.89 | -70.06 | 3.72 | -50.05 | -58.52 | -65.61 | -73.78 |
| 39.4 | 6.18 | -2.29 | -9.38 | -17.54 | 3.72 | 2.46 | -6.01 | -13.10 | -21.26 | -43.83 | -52.30 | -59.39 | -67.56 | 3.72 | -47.55 | -56.02 | -63.11 | -71.28 |
| 39.5 | 5.89 | -2.57 | -9.67 | -17.84 | 3.72 | 2.17 | -6.29 | -13.39 | -21.56 | -46.17 | -54.64 | -61.73 | -69.90 | 3.72 | -49.89 | -58.36 | -65.45 | -73.62 |
| 39.6 | 7.75 | -0.88 | -8.12 | -16.47 | 3.72 | 4.03 | -4.60 | -11.84 | -20.19 | -38.54 | -47.16 | -54.41 | -62.75 | 3.72 | -42.26 | -50.88 | -58.13 | -66.47 |
| 40.1 | 7.81 | -0.80 | -8.05 | -16.39 | 3.72 | 4.09 | -4.52 | -11.77 | -20.11 | -36.65 | -45.27 | -52.51 | -60.85 | 3.72 | -40.37 | -48.99 | -56.23 | -64.57 |
| 40.2 | 7.40 | -1.21 | -8.46 | -16.80 | 3.72 | 3.68 | -4.93 | -12.18 | -20.52 | -39.49 | -48.11 | -55.35 | -63.69 | 3.72 | -43.21 | -51.83 | -59.07 | -67.41 |
| 40.3 | 5.74 | -2.78 | -9.92 | -18.14 | 3.72 | 2.02 | -6.50 | -13.64 | -21.86 | -46.66 | -55.18 | -62.32 | -70.55 | 3.72 | -50.38 | -58.90 | -66.04 | -74.27 |
| 40.4 | -24.24 | -31.15 | -37.42 | -44.14 | 3.72 | -27.96 | -34.87 | -41.14 | -47.86 | -140.88 | -147.79 | -154.06 | -160.79 | 3.72 | -144.60 | -151.51 | -157.78 | -164.51 |
| 42.1 | 6.51 | -1.95 | -9.04 | -17.20 | 3.72 | 2.79 | -5.67 | -12.76 | -20.92 | -41.60 | -50.07 | -57.15 | -65.32 | 3.72 | -45.32 | -53.79 | -60.87 | -69.04 |
| 42.2 | 6.14 | -2.33 | -9.42 | -17.58 | 3.72 | 2.42 | -6.05 | -13.14 | -21.30 | -43.87 | -52.34 | -59.43 | -67.59 | 3.72 | -47.59 | -56.06 | -63.15 | -71.31 |
| 42.3 | 6.18 | -2.29 | -9.38 | -17.55 | 3.72 | 2.46 | -6.01 | -13.10 | -21.27 | -43.84 | -52.30 | -59.39 | -67.56 | 3.72 | -47.56 | -56.02 | -63.11 | -71.28 |
| 42.4 | -14.36 | -21.16 | -27.24 | -33.85 | 3.72 | -18.08 | -24.88 | -30.96 | -37.57 | -103.51 | -110.32 | -116.39 | -123.01 | 3.72 | -107.23 | -114.04 | -120.11 | -126.73 |
| 42.5 | -20.25 | -27.07 | -33.15 | -39.77 | 3.72 | -23.97 | -30.79 | -36.87 | -43.49 | -150.10 | -156.91 | -162.99 | -169.62 | 3.72 | -153.82 | -160.63 | -166.71 | -173.34 |
| 44.1 | 9.50 | 0.79 | -6.58 | -15.04 | 3.72 | 5.78 | -2.93 | -10.30 | -18.76 | -31.27 | -39.98 | -47.34 | -55.80 | 3.72 | -34.99 | -43.70 | -51.06 | -59.52 |
| 44.2 | 9.50 | 0.79 | -6.58 | -15.04 | 3.72 | 5.78 | -2.93 | -10.30 | -18.76 | -31.27 | -39.98 | -47.34 | -55.80 | 3.72 | -34.99 | -43.70 | -51.06 | -59.52 |
| 44.3 | -11.58 | -18.56 | -24.94 | -31.68 | 3.72 | -15.30 | -22.28 | -28.66 | -35.40 | -105.31 | -112.29 | -118.67 | -125.40 | 3.72 | -109.03 | -116.01 | -122.39 | -129.12 |
| 45.1 | -12.30 | -19.29 | -25.67 | -32.42 | 3.72 | -16.02 | -23.01 | -29.39 | -36.14 | -115.14 | -122.12 | -128.51 | -135.25 | 3.72 | -118.86 | -125.84 | -132.23 | -138.97 |
| 45.2 | 9.50 | 0.79 | -6.58 | -15.04 | 3.72 | 5.78 | -2.93 | -10.30 | -18.76 | -31.27 | -39.98 | -47.34 | -55.80 | 3.72 | -34.99 | -43.70 | -51.06 | -59.52 |
| 45.3 | -7.85 | -16.56 | -23.93 | -32.39 | 3.72 | -11.57 | -20.28 | -27.65 | -36.11 | -48.62 | -57.32 | -64.69 | -73.15 | 3.72 | -52.34 | -61.04 | -68.41 | -76.87 |
| 47.1 | 6.00 | -2.47 | -9.56 | -17.72 | 3.72 | 2.28 | -6.19 | -13.28 | -21.44 | -44.01 | -52.48 | -59.57 | -67.74 | 3.72 | -47.73 | -56.20 | -63.29 | -71.46 |
| 47.2 | 5.93 | -2.54 | -9.63 | -17.80 | 3.72 | 2.21 | -6.26 | -13.35 | -21.52 | -44.09 | -52.55 | -59.64 | -67.81 | 3.72 | -47.81 | -56.27 | -63.36 | -71.53 |
| 47.3 | -37.84 | -44.66 | -50.75 | -57.38 | 3.72 | -41.56 | -48.38 | -54.47 | -61.10 | -216.50 | -223.32 | -229.41 | -236.04 | 3.72 | -220.22 | -227.04 | -233.13 | -239.76 |
| 47.4 | -14.22 | -21.02 | -27.11 | -33.72 | 3.72 | -17.94 | -24.74 | -30.83 | -37.44 | -73.69 | -80.50 | -86.58 | -93.20 | 3.72 | -77.41 | -84.22 | -90.30 | -96.92 |
| 47.5 | -26.10 | -32.90 | -38.97 | -45.58 | 3.72 | -29.82 | -36.62 | -42.69 | -49.30 | -144.89 | -151.69 | -157.76 | -164.37 | 3.72 | -148.61 | -155.41 | -161.48 | -168.09 |
| 54.1 | -19.06 | -25.97 | -32.24 | -38.96 | 3.72 | -22.78 | -29.69 | -35.96 | -42.68 | -106.18 | -113.09 | -119.36 | -126.08 | 3.72 | -109.90 | -116.81 | -123.08 | -129.80 |
| 57.1 | 6.18 | -2.29 | -9.38 | -17.54 | 3.72 | 2.46 | -6.01 | -13.10 | -21.26 | -43.83 | -52.30 | -59.39 | -67.56 | 3.72 | -47.55 | -56.02 | -63.11 | -71.28 |
| 58.1 | 10.11 | 1.35 | -6.09 | -14.67 | 3.72 | 6.39 | -2.37 | -9.81 | -18.39 | -27.57 | -36.33 | -43.78 | -52.36 | 3.72 | -31.29 | -40.05 | -47.50 | -56.08 |
| 59.1 | 9.58 | 0.87 | -6.49 | -14.96 | 3.72 | 5.86 | -2.85 | -10.21 | -18.68 | -30.93 | -39.64 | -47.01 | -55.47 | 3.72 | -34.65 | -43.36 | -50.73 | -59.19 |
| 59.2 | -19.23 | -26.20 | -32.58 | -39.32 | 3.72 | -22.95 | -29.92 | -36.30 | -43.04 | -112.30 | -119.28 | -125.66 | -132.40 | 3.72 | -116.02 | -123.00 | -129.38 | -136.12 |
| 59.3 | 9.05 | 0.34 | -7.02 | -15.48 | 3.72 | 5.33 | -3.38 | -10.74 | -19.20 | -33.95 | -42.65 | -50.02 | -58.48 | 3.72 | -37.67 | -46.37 | -53.74 | -62.20 |
| 59.4 | -8.00 | -16.71 | -24.08 | -32.54 | 3.72 | -11.72 | -20.43 | -27.80 | -36.26 | -48.77 | -57.48 | -64.84 | -73.30 | 3.72 | -52.49 | -61.20 | -68.56 | -77.02 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 59.5 | -18.17 | -25.15 | -31.53 | -38.28 | 3.72 | -21.89 | -28.87 | -35.25 | -42.00 | -105.58 | -112.56 | -118.94 | -125.69 | 3.72 | -109.30 | -116.28 | -122.66 | -129.41 |
| 59.6 | 8.83 | 0.12 | -7.25 | -15.71 | 3.72 | 5.11 | -3.60 | -10.97 | -19.43 | -33.89 | -42.60 | -49.97 | -58.43 | 3.72 | -37.61 | -46.32 | -53.69 | -62.15 |
| 59.9 | -INF | -INF | -INF | -INF | 3.72 | -INF | -INF | -INF | -INF | -INF | -INF | -INF | -INF | 3.72 | -INF | -INF | -INF | -INF |
| 62.1 | -35.51 | -42.44 | -48.71 | -55.45 | 3.72 | -39.23 | -46.16 | -52.43 | -59.17 | -203.48 | -210.40 | -216.68 | -223.42 | 3.72 | -207.20 | -214.12 | -220.40 | -227.14 |
| 62.2 | 8.66 | 0.04 | -7.20 | -15.54 | 3.72 | 4.94 | -3.68 | -10.92 | -19.26 | -31.62 | -40.24 | -47.49 | -55.83 | 3.72 | -35.34 | -43.96 | -51.21 | -59.55 |
| 62.3 | 7.72 | -0.90 | -8.15 | -16.49 | 3.72 | 4.00 | -4.62 | -11.87 | -20.21 | -38.57 | -47.19 | -54.44 | -62.78 | 3.72 | -42.29 | -50.91 | -58.16 | -66.50 |
| 62.4 | 8.10 | -0.52 | -7.76 | -16.10 | 3.72 | 4.38 | -4.24 | -11.48 | -19.82 | -36.36 | -44.98 | -52.22 | -60.56 | 3.72 | -40.08 | -48.70 | -55.94 | -64.28 |
| 62.5 | -15.20 | -22.12 | -28.39 | -35.12 | 3.72 | -18.92 | -25.84 | -32.11 | -38.84 | -122.60 | -129.51 | -135.78 | -142.51 | 3.72 | -126.32 | -133.23 | -139.50 | -146.23 |
| 62.6 | -22.09 | -29.01 | -35.29 | -42.02 | 3.72 | -25.81 | -32.73 | -39.01 | -45.74 | -163.48 | -170.39 | -176.67 | -183.40 | 3.72 | -167.20 | -174.11 | -180.39 | -187.12 |
| 63.1 | 6.14 | -2.33 | -9.42 | -17.58 | 3.72 | 2.42 | -6.05 | -13.14 | -21.30 | -43.87 | -52.34 | -59.43 | -67.59 | 3.72 | -47.59 | -56.06 | -63.15 | -71.31 |
| 64.1 | 5.44 | -3.02 | -10.10 | -18.27 | 3.72 | 1.72 | -6.74 | -13.82 | -21.99 | -48.01 | -56.47 | -63.55 | -71.71 | 3.72 | -51.73 | -60.19 | -67.27 | -75.43 |
| 64.2 | 5.44 | -3.02 | -10.10 | -18.27 | 3.72 | 1.72 | -6.74 | -13.82 | -21.99 | -48.01 | -56.47 | -63.55 | -71.71 | 3.72 | -51.73 | -60.19 | -67.27 | -75.43 |
| 64.3 | 6.25 | -2.21 | -9.30 | -17.47 | 3.72 | 2.53 | -5.93 | -13.02 | -21.19 | -43.76 | -52.22 | -59.31 | -67.48 | 3.72 | -47.48 | -55.94 | -63.03 | -71.20 |
| 67.1 | 5.73 | -2.73 | -9.83 | -18.00 | 3.72 | 2.01 | -6.45 | -13.55 | -21.72 | -46.33 | -54.80 | -61.89 | -70.06 | 3.72 | -50.05 | -58.52 | -65.61 | -73.78 |
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| 68.2 | -15.55 | -22.60 | -29.07 | -35.89 | 3.72 | -19.27 | -26.32 | -32.79 | -39.61 | -128.12 | -135.16 | -141.64 | -148.45 | 3.72 | -131.84 | -138.88 | -145.36 | -152.17 |
| 68.3 | 10.39 | 1.62 | -5.83 | -14.42 | 3.72 | 6.67 | -2.10 | -9.55 | -18.14 | -24.81 | -33.58 | -41.03 | -49.62 | 3.72 | -28.53 | -37.30 | -44.75 | -53.34 |
| 71.1 | -25.73 | -32.72 | -39.11 | -45.86 | 3.72 | -29.45 | -36.44 | -42.83 | -49.58 | -161.12 | -168.10 | -174.49 | -181.24 | 3.72 | -164.84 | -171.82 | -178.21 | -184.96 |
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| 73.1 | -35.23 | -42.15 | -48.43 | -55.17 | 3.72 | -38.95 | -45.87 | -52.15 | -58.89 | -203.20 | -210.12 | -216.40 | -223.13 | 3.72 | -206.92 | -213.84 | -220.12 | -226.85 |
| 73.2 | -21.18 | -28.08 | -34.34 | -41.06 | 3.72 | -24.90 | -31.80 | -38.06 | -44.78 | -120.45 | -127.35 | -133.61 | -140.33 | 3.72 | -124.17 | -131.07 | -137.33 | -144.05 |
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| 75.2 | 9.57 | 0.87 | -6.50 | -14.96 | 3.72 | 5.85 | -2.85 | -10.22 | -18.68 | -31.19 | -39.90 | -47.27 | -55.73 | 3.72 | -34.91 | -43.62 | -50.99 | -59.45 |
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| 78.3 | 6.21 | -2.25 | -9.34 | -17.51 | 3.72 | 2.49 | -5.97 | -13.06 | -21.23 | -43.80 | -52.26 | -59.35 | -67.52 | 3.72 | -47.52 | -55.98 | -63.07 | -71.24 |
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| 81.3 | 5.78 | -2.69 | -9.78 | -17.95 | 3.72 | 2.06 | -6.41 | -13.50 | -21.67 | -46.28 | -54.75 | -61.84 | -70.01 | 3.72 | -50.00 | -58.47 | -65.56 | -73.73 |
| 81.4 | 6.14 | -2.33 | -9.42 | -17.58 | 3.72 | 2.42 | -6.05 | -13.14 | -21.30 | -43.87 | -52.34 | -59.43 | -67.59 | 3.72 | -47.59 | -56.06 | -63.15 | -71.31 |
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| 84.2 | -29.92 | -36.74 | -42.83 | -49.45 | 3.72 | -33.64 | -40.46 | -46.55 | -53.17 | -208.58 | -215.40 | -221.49 | -228.11 | 3.72 | -212.30 | -219.12 | -225.21 | -231.83 |
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| 86.1 | 7.72 | -0.75 | -7.84 | -16.02 | 3.72 | 4.00 | -4.47 | -11.56 | -19.74 | -38.99 | -47.47 | -54.56 | -62.73 | 3.72 | -42.71 | -51.19 | -58.28 | -66.45 |
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| 88.1 | 7.75 | -0.87 | -8.12 | -16.45 | 3.72 | 4.03 | -4.59 | -11.84 | -20.17 | -36.72 | -45.34 | -52.58 | -60.92 | 3.72 | -40.44 | -49.06 | -56.30 | -64.64 |
| 88.2 | -25.67 | -32.59 | -38.86 | -45.59 | 3.72 | -29.39 | -36.31 | -42.58 | -49.31 | -147.74 | -154.66 | -160.93 | -167.66 | 3.72 | -151.46 | -158.38 | -164.65 | -171.38 |

| | | | | | | | | | | | | | | | | | | |
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| 88.3 | 7.82 | -0.80 | -8.04 | -16.38 | 3.72 | 4.10 | -4.52 | -11.76 | -20.10 | -36.64 | -45.26 | -52.50 | -60.84 | 3.72 | -40.36 | -48.98 | -56.22 | -64.56 |
| 89.1 | -17.88 | -24.80 | -31.07 | -37.80 | 3.72 | -21.60 | -28.52 | -34.79 | -41.52 | -99.26 | -106.18 | -112.45 | -119.18 | 3.72 | -102.98 | -109.90 | -116.17 | -122.90 |
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| 90.1 | 8.61 | -0.01 | -7.25 | -15.59 | 3.72 | 4.89 | -3.73 | -10.97 | -19.31 | -31.67 | -40.29 | -47.54 | -55.88 | 3.72 | -35.39 | -44.01 | -51.26 | -59.60 |
| 90.2 | 7.99 | -0.63 | -7.87 | -16.21 | 3.72 | 4.27 | -4.35 | -11.59 | -19.93 | -36.47 | -45.09 | -52.33 | -60.67 | 3.72 | -40.19 | -48.81 | -56.05 | -64.39 |
| 90.3 | 7.65 | -0.97 | -8.21 | -16.55 | 3.72 | 3.93 | -4.69 | -11.93 | -20.27 | -36.81 | -45.43 | -52.67 | -61.01 | 3.72 | -40.53 | -49.15 | -56.39 | -64.73 |
| 90.4 | 7.73 | -0.89 | -8.13 | -16.47 | 3.72 | 4.01 | -4.61 | -11.85 | -20.19 | -36.74 | -45.35 | -52.60 | -60.94 | 3.72 | -40.46 | -49.07 | -56.32 | -64.66 |
| 90.5 | 8.75 | 0.13 | -7.12 | -15.46 | 3.72 | 5.03 | -3.59 | -10.84 | -19.18 | -31.54 | -40.16 | -47.40 | -55.74 | 3.72 | -35.26 | -43.88 | -51.12 | -59.46 |
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| 94.1 | -43.55 | -50.47 | -56.75 | -63.48 | 3.72 | -47.27 | -54.19 | -60.47 | -67.20 | -253.50 | -260.43 | -266.70 | -273.44 | 3.72 | -257.22 | -264.15 | -270.42 | -277.16 |
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| 108.1 | 11.93 | 3.19 | -4.25 | -12.81 | 3.72 | 8.21 | -0.53 | -7.97 | -16.53 | -26.36 | -35.11 | -42.55 | -51.11 | 3.72 | -30.08 | -38.83 | -46.27 | -54.83 |
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| 112.1 | 9.50 | 0.79 | -6.58 | -15.04 | 3.72 | 5.78 | -2.93 | -10.30 | -18.76 | -31.27 | -39.98 | -47.34 | -55.80 | 3.72 | -34.99 | -43.70 | -51.06 | -59.52 |
| 112.2 | -11.06 | -18.23 | -24.62 | -31.36 | 3.72 | -14.78 | -21.95 | -28.34 | -35.08 | -98.47 | -105.65 | -112.03 | -118.77 | 3.72 | -102.19 | -109.37 | -115.75 | -122.49 |
| 112.3 | -20.08 | -27.06 | -33.45 | -40.20 | 3.72 | -23.80 | -30.78 | -37.17 | -43.92 | -136.96 | -143.95 | -150.34 | -157.08 | 3.72 | -140.68 | -147.67 | -154.06 | -160.80 |
| 115.1 | -16.00 | -22.91 | -29.18 | -35.92 | 3.72 | -19.72 | -26.63 | -32.90 | -39.64 | -97.37 | -104.29 | -110.56 | -117.29 | 3.72 | -101.09 | -108.01 | -114.28 | -121.01 |
| 116.1 | 6.11 | -2.36 | -9.44 | -17.61 | 3.72 | 2.39 | -6.08 | -13.16 | -21.33 | -43.90 | -52.37 | -59.45 | -67.62 | 3.72 | -47.62 | -56.09 | -63.17 | -71.34 |
| 116.2 | 7.08 | -1.39 | -8.48 | -16.64 | 3.72 | 3.36 | -5.11 | -12.20 | -20.36 | -38.23 | -46.70 | -53.79 | -61.96 | 3.72 | -41.95 | -50.42 | -57.51 | -65.68 |
| 116.3 | -20.31 | -27.11 | -33.19 | -39.80 | 3.72 | -24.03 | -30.83 | -36.91 | -43.52 | -130.87 | -137.67 | -143.75 | -150.36 | 3.72 | -134.59 | -141.39 | -147.47 | -154.08 |
| 116.4 | -24.05 | -30.86 | -36.94 | -43.55 | 3.72 | -27.77 | -34.58 | -40.66 | -47.27 | -133.80 | -140.60 | -146.68 | -153.29 | 3.72 | -137.52 | -144.32 | -150.40 | -157.01 |
| 118.1 | -13.33 | -20.36 | -26.82 | -33.62 | 3.72 | -17.05 | -24.08 | -30.54 | -37.34 | -104.87 | -111.90 | -118.37 | -125.17 | 3.72 | -108.59 | -115.62 | -122.09 | -128.89 |
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| 118.3 | 5.70 | -3.06 | -10.51 | -19.09 | 3.72 | 1.98 | -6.78 | -14.23 | -22.81 | -52.33 | -61.09 | -68.54 | -77.12 | 3.72 | -56.05 | -64.81 | -72.26 | -80.84 |
| 122.1 | 10.39 | 1.64 | -5.80 | -14.36 | 3.72 | 6.67 | -2.08 | -9.52 | -18.08 | -29.74 | -38.49 | -45.93 | -54.49 | 3.72 | -33.46 | -42.21 | -49.65 | -58.21 |
| 122.2 | 6.14 | -2.33 | -9.42 | -17.58 | 3.72 | 2.42 | -6.05 | -13.14 | -21.30 | -43.87 | -52.34 | -59.43 | -67.59 | 3.72 | -47.59 | -56.06 | -63.15 | -71.31 |
| 123.1 | 7.35 | -1.27 | -8.52 | -16.86 | 3.72 | 3.63 | -4.99 | -12.24 | -20.58 | -38.94 | -47.56 | -54.81 | -63.15 | 3.72 | -42.66 | -51.28 | -58.53 | -66.87 |
| 123.2 | 7.51 | -1.11 | -8.36 | -16.70 | 3.72 | 3.79 | -4.83 | -12.08 | -20.42 | -38.78 | -47.40 | -54.65 | -62.99 | 3.72 | -42.50 | -51.12 | -58.37 | -66.71 |
| 124.1 | 7.71 | -0.91 | -8.15 | -16.49 | 3.72 | 3.99 | -4.63 | -11.87 | -20.21 | -36.75 | -45.37 | -52.61 | -60.95 | 3.72 | -40.47 | -49.09 | -56.33 | -64.67 |
| 124.2 | 7.71 | -0.91 | -8.15 | -16.49 | 3.72 | 3.99 | -4.63 | -11.87 | -20.21 | -36.75 | -45.37 | -52.61 | -60.95 | 3.72 | -40.47 | -49.09 | -56.33 | -64.67 |
| 124.3 | 10.75 | 2.01 | -5.43 | -13.99 | 3.72 | 7.03 | -1.71 | -9.15 | -17.71 | -27.54 | -36.29 | -43.73 | -52.29 | 3.72 | -31.26 | -40.01 | -47.45 | -56.01 |
| 124.4 | 10.75 | 2.01 | -5.43 | -13.99 | 3.72 | 7.03 | -1.71 | -9.15 | -17.71 | -27.54 | -36.29 | -43.73 | -52.29 | 3.72 | -31.26 | -40.01 | -47.45 | -56.01 |
| 127.1 | -19.89 | -26.92 | -33.39 | -40.20 | 3.72 | -23.61 | -30.64 | -37.11 | -43.92 | -115.03 | -122.07 | -128.54 | -135.34 | 3.72 | -118.75 | -125.79 | -132.26 | -139.06 |
| 127.2 | -21.70 | -28.73 | -35.19 | -41.98 | 3.72 | -25.42 | -32.45 | -38.91 | -45.70 | -126.36 | -133.38 | -139.84 | -146.64 | 3.72 | -130.08 | -137.10 | -143.56 | -150.36 |
| 129.1 | 7.26 | -1.35 | -8.60 | -16.93 | 3.72 | 3.54 | -5.07 | -12.32 | -20.65 | -39.63 | -48.25 | -55.49 | -63.83 | 3.72 | -43.35 | -51.97 | -59.21 | -67.55 |
| 129.2 | -15.92 | -22.64 | -28.91 | -35.63 | 3.72 | -19.64 | -26.36 | -32.63 | -39.35 | -111.79 | -118.51 | -124.78 | -131.51 | 3.72 | -115.51 | -122.23 | -128.50 | -135.23 |
| 129.3 | -14.77 | -21.67 | -27.94 | -34.66 | 3.72 | -18.49 | -25.39 | -31.66 | -38.38 | -119.49 | -126.39 | -132.65 | -139.37 | 3.72 | -123.21 | -130.11 | -136.37 | -143.09 |
| 130.1 | -15.89 | -22.93 | -29.39 | -36.20 | 3.72 | -19.61 | -26.65 | -33.11 | -39.92 | -101.18 | -108.22 | -114.69 | -121.49 | 3.72 | -104.90 | -111.94 | -118.41 | -125.21 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 130.2 | -16.29 | -23.32 | -29.79 | -36.59 | 3.72 | -20.01 | -27.04 | -33.51 | -40.31 | -93.58 | -100.61 | -107.08 | -113.88 | 3.72 | -97.30 | -104.33 | -110.80 | -117.60 |
| 130.3 | 9.84 | 1.08 | -6.37 | -14.95 | 3.72 | 6.12 | -2.64 | -10.09 | -18.67 | -27.84 | -36.60 | -44.05 | -52.63 | 3.72 | -31.56 | -40.32 | -47.77 | -56.35 |
| 130.4 | -13.31 | -20.34 | -26.81 | -33.61 | 3.72 | -17.03 | -24.06 | -30.53 | -37.33 | -104.86 | -111.89 | -118.35 | -125.15 | 3.72 | -108.58 | -115.61 | -122.07 | -128.87 |
| 131.1 | 10.25 | 1.49 | -5.96 | -14.54 | 3.72 | 6.53 | -2.23 | -9.68 | -18.26 | -27.44 | -36.20 | -43.65 | -52.22 | 3.72 | -31.16 | -39.92 | -47.37 | -55.94 |
| 131.2 | -12.32 | -19.35 | -25.81 | -32.62 | 3.72 | -16.04 | -23.07 | -29.53 | -36.34 | -108.89 | -115.92 | -122.38 | -129.18 | 3.72 | -112.61 | -119.64 | -126.10 | -132.90 |
| 133.1 | 9.43 | 0.67 | -6.78 | -15.36 | 3.72 | 5.71 | -3.05 | -10.50 | -19.08 | -32.62 | -41.38 | -48.82 | -57.40 | 3.72 | -36.34 | -45.10 | -52.54 | -61.12 |
| 133.2 | 9.30 | 0.53 | -6.93 | -15.52 | 3.72 | 5.58 | -3.19 | -10.65 | -19.24 | -31.61 | -40.38 | -47.84 | -56.42 | 3.72 | -35.33 | -44.10 | -51.56 | -60.14 |
| 133.3 | 9.58 | 0.81 | -6.64 | -15.22 | 3.72 | 5.86 | -2.91 | -10.36 | -18.94 | -29.65 | -38.41 | -45.87 | -54.45 | 3.72 | -33.37 | -42.13 | -49.59 | -58.17 |
| 134.1 | -51.49 | -58.32 | -64.42 | -71.05 | 3.72 | -55.21 | -62.04 | -68.14 | -74.77 | -298.26 | -305.09 | -311.19 | -317.82 | 3.72 | -301.98 | -308.81 | -314.91 | -321.54 |
| 134.2 | -33.78 | -40.58 | -46.65 | -53.26 | 3.72 | -37.50 | -44.30 | -50.37 | -56.98 | -192.17 | -198.97 | -205.04 | -211.65 | 3.72 | -195.89 | -202.69 | -208.76 | -215.37 |
| 134.3 | -18.11 | -24.92 | -31.00 | -37.62 | 3.72 | -21.83 | -28.64 | -34.72 | -41.34 | -97.86 | -104.68 | -110.76 | -117.38 | 3.72 | -101.58 | -108.40 | -114.48 | -121.10 |
| 134.4 | 6.51 | -1.95 | -9.04 | -17.20 | 3.72 | 2.79 | -5.67 | -12.76 | -20.92 | -41.60 | -50.07 | -57.15 | -65.32 | 3.72 | -45.32 | -53.79 | -60.87 | -69.04 |
| 135.1 | 7.71 | -0.91 | -8.15 | -16.49 | 3.72 | 3.99 | -4.63 | -11.87 | -20.21 | -36.75 | -45.37 | -52.61 | -60.95 | 3.72 | -40.47 | -49.09 | -56.33 | -64.67 |
| 135.2 | -23.96 | -30.87 | -37.14 | -43.86 | 3.72 | -27.68 | -34.59 | -40.86 | -47.58 | -158.12 | -165.03 | -171.30 | -178.02 | 3.72 | -161.84 | -168.75 | -175.02 | -181.74 |
| 135.3 | -35.23 | -42.15 | -48.43 | -55.17 | 3.72 | -38.95 | -45.87 | -52.15 | -58.89 | -203.20 | -210.12 | -216.40 | -223.13 | 3.72 | -206.92 | -213.84 | -220.12 | -226.85 |
| 135.4 | 10.82 | 2.08 | -5.37 | -13.92 | 3.72 | 7.10 | -1.64 | -9.09 | -17.64 | -27.48 | -36.22 | -43.66 | -52.22 | 3.72 | -31.20 | -39.94 | -47.38 | -55.94 |
| 135.5 | 9.88 | 1.13 | -6.30 | -14.86 | 3.72 | 6.16 | -2.59 | -10.02 | -18.58 | -33.16 | -41.90 | -49.34 | -57.89 | 3.72 | -36.88 | -45.62 | -53.06 | -61.61 |
| 135.6 | -19.06 | -26.09 | -32.55 | -39.35 | 3.72 | -22.78 | -29.81 | -36.27 | -43.07 | -122.04 | -129.07 | -135.54 | -142.34 | 3.72 | -125.76 | -132.79 | -139.26 | -146.06 |
| 137.1 | -8.89 | -17.51 | -24.76 | -33.09 | 3.72 | -12.61 | -21.23 | -28.48 | -36.81 | -53.36 | -61.97 | -69.22 | -77.56 | 3.72 | -57.08 | -65.69 | -72.94 | -81.28 |
| 138.1 | 8.11 | -0.51 | -7.75 | -16.08 | 3.72 | 4.39 | -4.23 | -11.47 | -19.80 | -34.67 | -43.28 | -50.53 | -58.86 | 3.72 | -38.39 | -47.00 | -54.25 | -62.58 |
| 138.2 | 7.98 | -0.64 | -7.88 | -16.22 | 3.72 | 4.26 | -4.36 | -11.60 | -19.94 | -36.48 | -45.10 | -52.34 | -60.68 | 3.72 | -40.20 | -48.82 | -56.06 | -64.40 |
| 138.3 | -13.09 | -20.00 | -26.27 | -33.00 | 3.72 | -16.81 | -23.72 | -29.99 | -36.72 | -80.17 | -87.08 | -93.35 | -100.08 | 3.72 | -83.89 | -90.80 | -97.07 | -103.80 |
| 143.1 | 6.22 | -2.25 | -9.34 | -17.51 | 3.72 | 2.50 | -5.97 | -13.06 | -21.23 | -43.80 | -52.26 | -59.35 | -67.52 | 3.72 | -47.52 | -55.98 | -63.07 | -71.24 |
| 143.2 | 5.81 | -2.65 | -9.75 | -17.92 | 3.72 | 2.09 | -6.37 | -13.47 | -21.64 | -46.25 | -54.72 | -61.81 | -69.98 | 3.72 | -49.97 | -58.44 | -65.53 | -73.70 |
| 143.3 | 6.41 | -2.06 | -9.15 | -17.31 | 3.72 | 2.69 | -5.78 | -12.87 | -21.03 | -43.60 | -52.07 | -59.16 | -67.32 | 3.72 | -47.32 | -55.79 | -62.88 | -71.04 |
| 144.1 | -34.26 | -41.06 | -47.14 | -53.74 | 3.72 | -37.98 | -44.78 | -50.86 | -57.46 | -224.33 | -231.13 | -237.20 | -243.81 | 3.72 | -228.05 | -234.85 | -240.92 | -247.53 |
| 145.1 | -28.95 | -35.86 | -42.13 | -48.86 | 3.72 | -32.67 | -39.58 | -45.85 | -52.58 | -185.05 | -191.96 | -198.24 | -204.97 | 3.72 | -188.77 | -195.68 | -201.96 | -208.69 |
| 145.2 | -23.92 | -30.83 | -37.10 | -43.83 | 3.72 | -27.64 | -34.55 | -40.82 | -47.55 | -156.80 | -163.71 | -169.98 | -176.71 | 3.72 | -160.52 | -167.43 | -173.70 | -180.43 |
| 145.3 | -13.22 | -20.13 | -26.40 | -33.12 | 3.72 | -16.94 | -23.85 | -30.12 | -36.84 | -110.42 | -117.33 | -123.60 | -130.32 | 3.72 | -114.14 | -121.05 | -127.32 | -134.04 |
| 146.1 | 7.36 | -1.27 | -8.51 | -16.86 | 3.72 | 3.64 | -4.99 | -12.23 | -20.58 | -38.93 | -47.55 | -54.80 | -63.14 | 3.72 | -42.65 | -51.27 | -58.52 | -66.86 |
| 146.2 | -15.22 | -22.13 | -28.39 | -35.12 | 3.72 | -18.94 | -25.85 | -32.11 | -38.84 | -112.42 | -119.33 | -125.59 | -132.32 | 3.72 | -116.14 | -123.05 | -129.31 | -136.04 |
| 147.1 | -24.25 | -31.15 | -37.42 | -44.13 | 3.72 | -27.97 | -34.87 | -41.14 | -47.85 | -135.93 | -142.83 | -149.10 | -155.81 | 3.72 | -139.65 | -146.55 | -152.82 | -159.53 |
| 148.1 | 10.93 | 2.17 | -5.28 | -13.86 | 3.72 | 7.21 | -1.55 | -9.00 | -17.58 | -23.21 | -31.97 | -39.42 | -48.00 | 3.72 | -26.93 | -35.69 | -43.14 | -51.72 |
| 148.2 | 9.91 | 1.15 | -6.30 | -14.88 | 3.72 | 6.19 | -2.57 | -10.02 | -18.60 | -27.77 | -36.53 | -43.98 | -52.56 | 3.72 | -31.49 | -40.25 | -47.70 | -56.28 |
| 148.3 | 10.03 | 1.27 | -6.18 | -14.77 | 3.72 | 6.31 | -2.45 | -9.90 | -18.49 | -29.20 | -37.96 | -45.41 | -54.00 | 3.72 | -32.92 | -41.68 | -49.13 | -57.72 |
| 150.1 | 5.63 | -2.83 | -9.92 | -18.09 | 3.72 | 1.91 | -6.55 | -13.64 | -21.81 | -47.12 | -55.58 | -62.67 | -70.84 | 3.72 | -50.84 | -59.30 | -66.39 | -74.56 |
| 150.2 | -12.69 | -19.70 | -25.78 | -32.39 | 3.72 | -16.41 | -23.42 | -29.50 | -36.11 | -100.79 | -107.79 | -113.87 | -120.49 | 3.72 | -104.51 | -111.51 | -117.59 | -124.21 |
| 151.1 | 6.17 | -2.29 | -9.38 | -17.55 | 3.72 | 2.45 | -6.01 | -13.10 | -21.27 | -43.84 | -52.31 | -59.39 | -67.56 | 3.72 | -47.56 | -56.03 | -63.11 | -71.28 |
| 151.2 | 6.20 | -2.26 | -9.35 | -17.52 | 3.72 | 2.48 | -5.98 | -13.07 | -21.24 | -43.81 | -52.27 | -59.36 | -67.53 | 3.72 | -47.53 | -55.99 | -63.08 | -71.25 |
| 152.1 | -29.52 | -36.56 | -43.02 | -49.82 | 3.72 | -33.24 | -40.28 | -46.74 | -53.54 | -185.60 | -192.64 | -199.10 | -205.90 | 3.72 | -189.32 | -196.36 | -202.82 | -209.62 |
| 155.1 | 0.23 | -3.03 | -5.79 | -8.97 | 3.72 | -3.49 | -6.75 | -9.51 | -12.69 | -31.15 | -34.42 | -37.18 | -40.35 | 3.72 | -34.87 | -38.14 | -40.90 | -44.07 |
| 156.1 | 7.71 | -0.91 | -8.15 | -16.49 | 3.72 | 3.99 | -4.63 | -11.87 | -20.21 | -36.75 | -45.37 | -52.61 | -60.95 | 3.72 | -40.47 | -49.09 | -56.33 | -64.67 |
| 156.2 | -37.37 | -44.27 | -50.54 | -57.25 | 3.72 | -41.09 | -47.99 | -54.26 | -60.97 | -216.06 | -222.96 | -229.22 | -235.94 | 3.72 | -219.78 | -226.68 | -232.94 | -239.66 |
| 156.3 | -30.95 | -37.99 | -44.45 | -51.25 | 3.72 | -34.67 | -41.71 | -48.17 | -54.97 | -187.03 | -194.07 | -200.53 | -207.33 | 3.72 | -190.75 | -197.79 | -204.25 | -211.05 |
| 157.1 | 7.40 | -1.23 | -8.48 | -16.82 | 3.72 | 3.68 | -4.95 | -12.20 | -20.54 | -38.89 | -47.52 | -54.76 | -63.11 | 3.72 | -42.61 | -51.24 | -58.48 | -66.83 |
| 157.2 | -17.96 | -24.87 | -31.14 | -37.87 | 3.72 | -21.68 | -28.59 | -34.86 | -41.59 | -133.64 | -140.55 | -146.82 | -153.55 | 3.72 | -137.36 | -144.27 | -150.54 | -157.27 |
| 159.1 | -20.05 | -27.02 | -33.39 | -40.13 | 3.72 | -23.77 | -30.74 | -37.11 | -43.85 | -126.98 | -133.96 | -140.33 | -147.06 | 3.72 | -130.70 | -137.68 | -144.05 | -150.78 |
| 160.1 | -24.78 | -31.82 | -38.30 | -45.11 | 3.72 | -28.50 | -35.54 | -42.02 | -48.83 | -183.48 | -190.52 | -197.00 | -203.81 | 3.72 | -187.20 | -194.24 | -200.72 | -207.53 |
| 161.1 | -13.61 | -20.61 | -26.69 | -33.31 | 3.72 | -17.33 | -24.33 | -30.41 | -37.03 | -106.27 | -113.28 | -119.36 | -125.97 | 3.72 | -109.99 | -117.00 | -123.08 | -129.69 |
| 161.2 | -30.65 | -37.66 | -43.75 | -50.38 | 3.72 | -34.37 | -41.38 | -47.47 | -54.10 | -209.31 | -216.32 | -222.41 | -229.04 | 3.72 | -213.03 | -220.04 | -226.13 | -232.76 |
| 162.1 | -21.91 | -28.93 | -35.38 | -42.16 | 3.72 | -25.63 | -32.65 | -39.10 | -45.88 | -132.14 | -139.16 | -145.60 | -152.38 | 3.72 | -135.86 | -142.88 | -149.32 | -156.10 |
| 163.1 | -32.85 | -39.84 | -46.24 | -52.99 | 3.72 | -36.57 | -43.56 | -49.96 | -56.71 | -193.69 | -200.68 | -207.07 | -213.82 | 3.72 | -197.41 | -204.40 | -210.79 | -217.54 |
| 163.2 | -34.91 | -41.89 | -48.26 | -54.99 | 3.72 | -38.63 | -45.61 | -51.98 | -58.71 | -248.79 | -255.76 | -262.14 | -268.87 | 3.72 | -252.51 | -259.48 | -265.86 | -272.59 |
| 164.1 | 6.64 | -1.98 | -9.22 | -17.55 | 3.72 | 2.92 | -5.70 | -12.94 | -21.27 | -43.32 | -51.93 | -59.17 | -67.51 | 3.72 | -47.04 | -55.65 | -62.89 | -71.23 |
| 165.1 | 6.65 | -1.96 | -9.20 | -17.54 | 3.72 | 2.93 | -5.68 | -12.92 | -21.26 | -43.31 | -51.92 | -59.16 | -67.50 | 3.72 | -47.03 | -55.64 | -62.88 | -71.22 |
| 165.2 | 5.28 | -3.32 | -10.56 | -18.89 | 3.72 | 1.56 | -7.04 | -14.28 | -22.61 | -51.71 | -60.32 | -67.56 | -75.89 | 3.72 | -55.43 | -64.04 | -71.28 | -79.61 |
| 166.1 | 7.83 | -0.79 | -8.04 | -16.38 | 3.72 | 4.11 | -4.51 | -11.76 | -20.10 | -36.09 | -44.71 | -51.96 | -60.30 | 3.72 | -39.81 | -48.43 | -55.68 | -64.02 |
| 166.2 | 6.45 | -2.15 | -9.39 | -17.72 | 3.72 | 2.73 | -5.87 | -13.11 | -21.44 | -44.21 | -52.82 | -60.06 | -68.39 | 3.72 | -47.93 | -56.54 | -63.78 | -72.11 |
| 168.1 | 9.84 | 1.08 | -6.37 | -14.95 | 3.72 | 6.12 | -2.64 | -10.09 | -18.67 | -27.84 | -36.60 | -44.05 | -52.63 | 3.72 | -31.56 | -40.32 | -47.77 | -56.35 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 170.1 | 7.37 | -1.26 | -8.50 | -16.85 | 3.72 | 3.65 | -4.98 | -12.22 | -20.57 | -38.92 | -47.54 | -54.79 | -63.13 | 3.72 | -42.64 | -51.26 | -58.51 | -66.85 |
| 170.2 | 7.88 | -0.74 | -7.99 | -16.33 | 3.72 | 4.16 | -4.46 | -11.71 | -20.05 | -36.59 | -45.21 | -52.45 | -60.79 | 3.72 | -40.31 | -48.93 | -56.17 | -64.51 |
| 171.1 | -22.84 | -29.87 | -36.34 | -43.14 | 3.72 | -26.56 | -33.59 | -40.06 | -46.86 | -171.77 | -178.80 | -185.27 | -192.07 | 3.72 | -175.49 | -182.52 | -188.99 | -195.79 |
| 171.2 | -19.82 | -26.86 | -33.33 | -40.13 | 3.72 | -23.54 | -30.58 | -37.05 | -43.85 | -154.28 | -161.31 | -167.78 | -174.59 | 3.72 | -158.00 | -165.03 | -171.50 | -178.31 |
| 176.1 | 7.71 | -0.91 | -8.15 | -16.49 | 3.72 | 3.99 | -4.63 | -11.87 | -20.21 | -36.75 | -45.37 | -52.61 | -60.95 | 3.72 | -40.47 | -49.09 | -56.33 | -64.67 |
| 177.1 | 6.54 | -2.06 | -9.30 | -17.63 | 3.72 | 2.82 | -5.78 | -13.02 | -21.35 | -44.12 | -52.73 | -59.97 | -68.30 | 3.72 | -47.84 | -56.45 | -63.69 | -72.02 |
| 179.1 | 7.71 | -0.91 | -8.15 | -16.49 | 3.72 | 3.99 | -4.63 | -11.87 | -20.21 | -36.75 | -45.37 | -52.61 | -60.95 | 3.72 | -40.47 | -49.09 | -56.33 | -64.67 |
| 179.2 | 7.71 | -0.91 | -8.15 | -16.49 | 3.72 | 3.99 | -4.63 | -11.87 | -20.21 | -36.75 | -45.37 | -52.61 | -60.95 | 3.72 | -40.47 | -49.09 | -56.33 | -64.67 |
| 179.3 | 10.75 | 2.01 | -5.43 | -13.99 | 3.72 | 7.03 | -1.71 | -9.15 | -17.71 | -27.54 | -36.29 | -43.73 | -52.29 | 3.72 | -31.26 | -40.01 | -47.45 | -56.01 |
| 179.4 | 11.16 | 2.41 | -5.03 | -13.58 | 3.72 | 7.44 | -1.31 | -8.75 | -17.30 | -27.14 | -35.89 | -43.33 | -51.88 | 3.72 | -30.86 | -39.61 | -47.05 | -55.60 |
| 179.5 | 7.71 | -0.91 | -8.15 | -16.49 | 3.72 | 3.99 | -4.63 | -11.87 | -20.21 | -36.75 | -45.37 | -52.61 | -60.95 | 3.72 | -40.47 | -49.09 | -56.33 | -64.67 |
| 179.6 | 10.75 | 2.01 | -5.43 | -13.99 | 3.72 | 7.03 | -1.71 | -9.15 | -17.71 | -27.54 | -36.29 | -43.73 | -52.29 | 3.72 | -31.26 | -40.01 | -47.45 | -56.01 |
| 179.7 | 7.71 | -0.91 | -8.15 | -16.49 | 3.72 | 3.99 | -4.63 | -11.87 | -20.21 | -36.75 | -45.37 | -52.61 | -60.95 | 3.72 | -40.47 | -49.09 | -56.33 | -64.67 |
| 179.8 | 7.71 | -0.91 | -8.15 | -16.49 | 3.72 | 3.99 | -4.63 | -11.87 | -20.21 | -36.75 | -45.37 | -52.61 | -60.95 | 3.72 | -40.47 | -49.09 | -56.33 | -64.67 |
| 179.9 | 7.71 | -0.91 | -8.15 | -16.49 | 3.72 | 3.99 | -4.63 | -11.87 | -20.21 | -36.75 | -45.37 | -52.61 | -60.95 | 3.72 | -40.47 | -49.09 | -56.33 | -64.67 |
| 179.10 | 10.75 | 2.01 | -5.43 | -13.99 | 3.72 | 7.03 | -1.71 | -9.15 | -17.71 | -27.54 | -36.29 | -43.73 | -52.29 | 3.72 | -31.26 | -40.01 | -47.45 | -56.01 |
| 179.11 | 10.75 | 2.01 | -5.43 | -13.99 | 3.72 | 7.03 | -1.71 | -9.15 | -17.71 | -27.54 | -36.29 | -43.73 | -52.29 | 3.72 | -31.26 | -40.01 | -47.45 | -56.01 |
| 179.12 | 10.75 | 2.01 | -5.43 | -13.99 | 3.72 | 7.03 | -1.71 | -9.15 | -17.71 | -27.54 | -36.29 | -43.73 | -52.29 | 3.72 | -31.26 | -40.01 | -47.45 | -56.01 |
| 179.13 | 10.79 | 2.04 | -5.40 | -13.95 | 3.72 | 7.07 | -1.68 | -9.12 | -17.67 | -27.51 | -36.26 | -43.70 | -52.25 | 3.72 | -31.23 | -39.98 | -47.42 | -55.97 |
| 179.14 | 7.75 | -0.87 | -8.12 | -16.45 | 3.72 | 4.03 | -4.59 | -11.84 | -20.17 | -36.72 | -45.34 | -52.58 | -60.92 | 3.72 | -40.44 | -49.06 | -56.30 | -64.64 |
| 179.15 | -24.96 | -31.87 | -38.14 | -44.86 | 3.72 | -28.68 | -35.59 | -41.86 | -48.58 | -141.61 | -148.52 | -154.78 | -161.51 | 3.72 | -145.33 | -152.24 | -158.50 | -165.23 |
| 180.1 | 7.71 | -0.91 | -8.15 | -16.49 | 3.72 | 3.99 | -4.63 | -11.87 | -20.21 | -36.75 | -45.37 | -52.61 | -60.95 | 3.72 | -40.47 | -49.09 | -56.33 | -64.67 |
| 180.2 | -14.05 | -21.16 | -27.43 | -34.15 | 3.72 | -17.77 | -24.88 | -31.15 | -37.87 | -111.26 | -118.36 | -124.63 | -131.35 | 3.72 | -114.98 | -122.08 | -128.35 | -135.07 |

[a] The consumptive value of water given it is available X years out of 10.

[b] The net value of water given it is available X years out of 10.

Table L-3. Municipal water costs

| Subbasin<br>Municipality | Proposed Requests<br>Thousands of Gallons/Year | Proposed Requests<br>Annual Total Costs | Proposed Requests<br>Costs Per Thousand Gallons | Current System Costs Per Thousand Gallons |
|---|---|---|---|---|
| **Milk** | | | | |
| Chinook | 65,170.2 | $42,776 | $0.66 | $1.42 |
| Harlem | 65,170.2 | $56,341 | $0.86 | $1.81 |
| Havre | 154,779.2 | $228,554 | $1.48 | $1.76 |
| Hill County W.D. | 35,843.6 | $24,742 | $0.69 | $2.68 |
| Malta | 44,641.6 | $43,011 | $0.96 | $0.70 |
| **Little Missouri** | | | | |
| Ekalaka | 6,517.0 | $12,643 | $1.94 | $1.88 |
| Wibaux | 23,005.1 | $35,863 | $1.56 | $1.94 |
| **Lower Missouri** | | | | |
| Circle | 25,416.4 | $36,926 | $1.45 | $2.08 |
| Culbertson | 118,935.6 | $34,091 | $0.29 | $1.04 |
| Fort Peck | 32,585.1 | $24,328 | $0.75 | $0.65 |
| Poplar | 145,981.2 | $34,190 | $0.23 | $1.15 |
| Wolf Point | 164,228.9 | $30,854 | $0.19 | $1.02 |
| Scobey | 54,743.0 | $20,936 | $0.38 | $1.45 |
| **Sheridan County** | | | | |
| Plentywood | 76,575.0 | $29,453 | $0.38 | $0.77 |

Source: Information based on municipal water reservation applications submitted to DNRC

Table L-4. Instream values ($/af)

| Subbasin | Recreational Value (during)<br>July & August | Recreational Value (during)<br>Rest-of-Year | Hydropower Value (assuming)<br>5 cents/kWh | Hydropower Value (assuming)<br>10 cents/kWh |
|---|---|---|---|---|
| Milk | 5.81 | 1.63 | 25.96 | 51.92 |
| Little Missouri | 5.81 | 1.63 | 25.96 | 51.92 |
| Lower Missouri | 5.81 | 1.63 | 25.96 | 51.92 |
| Sheridan County | 5.81 | 1.63 | 0.00 | 0.00 |

**Table L-5. Net revenues from existing dryland farming/ranching operations and from the proposed irrigated operations in the Lower Missouri, Milk, and Little Missouri River subbasins**

| Subbasin<br>Drainage<br>Project | Net Revenues from Proposed Irrigated Operations Given Water Availability for X Years out of 10 ($/ac) (a) | | | | Net Revenues from Existing Farm & Ranch Operations ($/ac) (a) |
|---|---|---|---|---|---|
| | 10/10 | 8/10 | 6/10 | 4/10 | |
| Lower Missouri | | | | | |
| Missouri River | | | | | |
| VA-01 | 1223.75 | 706.05 | 266.28 | -234.66 | 969.90 |
| VA-02 | 551.83 | 109.14 | -263.65 | -686.08 | 358.34 |
| VA-03 | 1004.78 | 513.12 | 106.25 | -362.18 | 242.80 |
| VA-231 | 952.62 | 441.33 | 8.86 | -487.99 | 578.51 |
| MC-01 | 1355.58 | 883.14 | 475.93 | 6.11 | 269.28 |
| MC-03 | 1620.76 | 1088.74 | 634.10 | 124.79 | 347.00 |
| MC-04 | 980.45 | 431.44 | -31.62 | -546.34 | 168.95 |
| MC-05 | 921.10 | 417.33 | -7.47 | -496.71 | 295.85 |
| MC-5A | 956.29 | 418.26 | -39.91 | -553.27 | 82.54 |
| MC-06 | 1482.90 | 944.64 | 486.33 | -27.02 | 75.73 |
| MC-6A | 848.58 | 302.96 | -157.79 | -672.89 | 180.34 |
| MC-08 | 902.17 | 421.05 | 21.66 | -436.72 | 340.30 |
| MC-09 | 1312.58 | 779.80 | 324.72 | -185.19 | 41.86 |
| MC-9A | 466.69 | -63.93 | -517.28 | -1025.96 | 488.76 |
| MC-10 | 684.96 | 190.90 | -225.06 | -702.68 | 322.29 |
| MC-11 | 885.74 | 429.51 | 35.98 | -415.55 | 264.68 |
| MC-12 | 504.99 | 19.32 | -383.12 | -845.74 | 168.31 |
| MC-99 | 1249.14 | 761.15 | 357.15 | -107.63 | 369.66 |
| RI-01 | 1074.12 | 618.63 | 226.03 | -225.20 | 282.95 |
| RI-02 | 1320.55 | 835.08 | 432.77 | -29.67 | 169.34 |
| RI-03 | 1265.57 | 800.23 | 410.68 | -31.12 | 75.01 |
| RI-04 | 1565.73 | 1050.72 | 614.37 | 114.37 | 380.88 |
| RI-05 | 1617.22 | 1096.38 | 652.62 | 149.64 | 906.93 |
| RI-06 | 1623.69 | 1091.26 | 636.39 | 126.75 | 648.38 |
| RI-07 | 443.86 | 3.48 | -368.32 | -789.72 | 371.19 |
| RI-08 | 746.22 | 326.20 | -37.58 | -449.14 | 358.34 |
| RI-09 | 1132.24 | 651.85 | 252.94 | -204.72 | 589.56 |
| RI-10 | 1225.04 | 753.12 | 359.89 | -88.58 | 227.63 |
| RI-11A | 1377.89 | 845.57 | 390.77 | -118.78 | 403.59 |
| RI-11 | 1769.71 | 1261.16 | 830.60 | 337.54 | 248.11 |
| RI-12 | 1352.01 | 830.39 | 385.74 | -118.04 | 213.27 |
| RI-13 | 1056.45 | 520.52 | 63.58 | -448.80 | 92.44 |
| RI-14 | 1163.70 | 669.73 | 254.09 | -223.27 | 211.81 |
| RI-15 | 606.55 | 132.95 | -261.41 | -711.70 | 194.05 |
| CBI-1 | 2003.93 | 1496.40 | 1067.06 | 574.90 | 537.01 |
| CBI-2 | 882.19 | 431.03 | 43.86 | -392.88 | 327.20 |
| CBI-3 | 1191.04 | 726.03 | 323.61 | -134.15 | 356.40 |
| CBI-4 | 278.80 | -158.45 | -531.86 | -948.96 | 343.70 |
| CBI-5 | 736.07 | 237.12 | -183.77 | -668.82 | 399.85 |
| CBI-6 | 1027.35 | 544.25 | 143.52 | -316.71 | 261.87 |
| CBI-7 | -109.58 | -611.11 | -1033.66 | -1521.38 | 336.12 |
| CBI-8 | 844.30 | 466.00 | 133.43 | -233.11 | 334.27 |
| CBI-9 | 458.64 | 73.29 | -270.49 | -642.99 | 358.34 |
| CBI-10 | 820.38 | 409.70 | 46.30 | -351.75 | 309.27 |
| CBI-11 | 695.65 | 288.04 | -75.44 | -467.45 | 407.22 |
| CBI-12 | 163.64 | -216.35 | -551.59 | -918.70 | 339.08 |
| CBI-13 | -48.34 | -383.98 | -670.96 | -999.77 | 343.12 |
| CBI-14 | 1375.53 | 898.50 | 489.51 | 13.69 | 298.33 |
| CBI-15 | 712.84 | 346.36 | 12.08 | -348.30 | 234.84 |

| | | | | | |
|---|---|---|---|---|---|
| CBI-16 | 991.36 | 559.70 | 188.24 | -226.50 | 353.86 |
| CBI-17 | 1102.25 | 656.67 | 281.16 | -140.22 | 234.83 |
| CBI-18 | 538.57 | 152.65 | -181.99 | -560.75 | 358.34 |
| CBI-19 | 1376.34 | 904.06 | 496.97 | 27.41 | 185.26 |
| CBI-20 | 795.33 | 331.38 | -70.35 | -526.66 | 46.58 |
| CBI-21 | 529.10 | 135.59 | -236.01 | -646.37 | 46.58 |
| Poplar River | | | | | |
| DA-21WS | 349.65 | 152.00 | 24.71 | -162.67 | 37.09 |
| DA-31 | 1053.50 | 560.57 | 148.90 | -324.32 | 326.98 |
| DA-32 | 1106.97 | 558.73 | 96.18 | -418.62 | 358.34 |
| DA-51 | 1429.91 | 1004.94 | 639.77 | 225.27 | 358.34 |
| DA-71 | 1475.63 | 989.05 | 585.99 | 122.52 | 41.72 |
| DA-131WS | 349.65 | 152.00 | 24.71 | -162.67 | 358.34 |
| DA-151 | 1905.64 | 1384.19 | 939.70 | 436.11 | 358.34 |
| DA-152WS | 349.65 | 152.00 | 24.71 | -162.67 | 30.98 |
| DA-153WS | 349.65 | 152.00 | 24.71 | -162.67 | 358.34 |
| DA-161 | -91.37 | -555.24 | -943.35 | -1383.26 | 457.33 |
| DA-181WS | 349.65 | 152.00 | 24.71 | -162.67 | 287.79 |
| DA-182WS | 349.65 | 152.00 | 24.71 | -162.67 | 47.91 |
| DA-211 | 409.43 | 0.98 | -362.48 | -756.13 | 41.67 |
| DA-221 | 1775.35 | 1230.43 | 770.16 | 254.98 | 41.72 |
| DA-251 | 1325.08 | 784.07 | 325.83 | -189.15 | 287.69 |
| DA-252 | 1499.56 | 998.08 | 575.55 | 87.88 | 358.34 |
| DA-261 | 1342.02 | 845.36 | 425.94 | -56.74 | 314.79 |
| DA-281 | -271.14 | -635.36 | -948.74 | -1297.70 | 193.97 |
| DA-291WS | 159.90 | -37.75 | -165.04 | -352.42 | 285.26 |
| DA-341 | 1229.81 | 678.76 | 214.71 | -301.58 | 30.98 |
| DA-371WS | 349.65 | 152.00 | 24.71 | -162.67 | 37.09 |
| Milk River | | | | | |
| LI-241 | -330.01 | -807.64 | -1204.70 | -1659.37 | 408.68 |
| BL-131 | -264.31 | -824.46 | -1294.80 | -1826.94 | 372.93 |
| BL-171 | -239.30 | -840.69 | -1352.02 | -1921.85 | 48.69 |
| BL-181 | Discussed in Table L-6. | | | | |
| VA-71 | 1098.74 | 578.35 | 135.16 | -367.41 | 801.19 |
| VA-171 | 1614.29 | 1125.14 | 720.36 | 254.50 | 358.34 |
| VA-211 | 1069.26 | 525.92 | 66.72 | -448.64 | 730.29 |
| VA-261 | 1223.55 | 681.15 | 222.59 | -292.88 | 337.35 |
| VA-291 | 669.17 | 247.89 | -115.69 | -528.54 | 358.34 |
| VA-521 | 1349.94 | 808.69 | 350.47 | -164.66 | 329.32 |
| Little Missouri | | | | | |
| Little Missouri River | | | | | |
| CT-011 | 919.63 | 542.19 | 211.06 | -154.63 | 100.25 |
| CT-012WS | 301.62 | 92.75 | -47.97 | -245.65 | 208.95 |
| CT-131 | 1291.01 | 914.32 | 584.53 | 220.07 | 32.36 |
| CT-141WS | 489.74 | 289.85 | 118.12 | -92.59 | 33.72 |
| CT-161WS | 489.74 | 289.85 | 118.12 | -92.59 | 35.81 |
| CT-162WS | 489.74 | 289.85 | 118.12 | -92.59 | 35.81 |
| CT-181WS | 301.62 | 92.75 | -47.97 | -245.65 | 32.36 |
| CT-191 | 220.61 | -79.75 | -325.54 | -600.95 | 35.92 |
| CT-241 | 805.98 | 387.41 | 23.17 | -386.66 | 32.36 |
| CT-243WS | 489.74 | 289.85 | 118.12 | -92.59 | 36.34 |
| CT-244WS | 489.74 | 289.85 | 118.12 | -92.59 | 34.09 |
| Boxelder Creek | | | | | |
| CT-121 | 550.18 | 198.19 | -88.27 | -419.22 | 358.34 |
| CT-122WS | 489.74 | 289.85 | 118.12 | -92.59 | 358.34 |
| CT-151WS | 489.74 | 289.85 | 118.12 | -92.59 | 38.20 |
| CT-152WS | 489.74 | 289.85 | 118.12 | -92.59 | 39.77 |
| CT-153WS | 489.74 | 289.85 | 118.12 | -92.59 | 40.61 |
| CT-154WS | 489.74 | 289.85 | 118.12 | -92.59 | 39.14 |
| CT-171WS | 301.62 | 92.75 | -47.97 | -245.65 | 30.24 |
| CT-221 | 1149.03 | 761.92 | 415.08 | 41.74 | 457.33 |
| CT-251 | 872.10 | 497.74 | 170.59 | -190.95 | 37.00 |

| | | | | | |
|---|---|---|---|---|---|
| CT-261WS | 489.74 | 289.85 | 118.12 | -92.59 | 33.82 |
| CT-262WS | 489.74 | 289.85 | 118.12 | -92.59 | 33.82 |
| CT-310WS | 489.74 | 289.85 | 118.12 | -92.59 | 29.71 |
| CT-320 | 342.62 | -221.07 | -694.61 | -1233.69 | 457.33 |
| CT-330 | 1112.10 | 750.52 | 443.67 | 98.76 | 38.75 |
| CT-370 | 853.97 | 464.82 | 115.21 | -261.36 | 358.34 |
| CT-380 | 288.73 | -76.47 | -392.27 | -742.74 | 457.33 |
| Little Beaver Creek | | | | | |
| LB-061WS | 489.74 | 289.85 | 118.12 | -92.59 | 43.38 |
| LB-063WS | 489.74 | 289.85 | 118.12 | -92.59 | 43.38 |
| LB-083WS | 489.74 | 289.85 | 118.12 | -92.59 | 50.66 |
| LB-141WS | 301.62 | 92.75 | -47.97 | -245.65 | 46.11 |
| LB-151WS | 489.74 | 289.85 | 118.12 | -92.59 | 83.86 |
| LB-181WS | 489.74 | 289.85 | 118.12 | -92.59 | 34.15 |
| LB-182WS | 489.74 | 289.85 | 118.12 | -92.59 | 38.27 |
| CT-041WS | 301.62 | 92.75 | -47.97 | -245.65 | 43.68 |
| CT-071 | 1626.34 | 1112.52 | 677.67 | 178.08 | 43.68 |
| CT-291WS | 489.74 | 289.85 | 118.12 | -92.59 | 47.17 |
| CT-293WS | 489.74 | 289.85 | 118.12 | -92.59 | 52.77 |
| CT-294 | 30.36 | -485.30 | -922.48 | -1422.71 | 358.34 |
| CT-301WS | 301.62 | 92.75 | -47.97 | -245.65 | 372.53 |
| CT-340WS | 301.62 | 92.75 | -47.97 | -245.65 | 40.45 |
| Beaver Creek | | | | | |
| WI-41WS | 489.74 | 289.85 | 118.12 | -92.59 | 358.34 |
| WI-42WS | 301.62 | 92.75 | -47.97 | -245.65 | 352.13 |
| WI-43WS | 489.74 | 289.85 | 118.12 | -92.59 | 44.92 |
| WI-61WS | 489.74 | 289.85 | 118.12 | -92.59 | 208.76 |
| WI-71WS | 489.74 | 289.85 | 118.12 | -92.59 | 53.07 |
| WI-72WS | 489.74 | 289.85 | 118.12 | -92.59 | 53.07 |
| WI-73WS | 301.62 | 92.75 | -47.97 | -245.65 | 372.53 |
| WI-74WS | 489.74 | 289.85 | 118.12 | -92.59 | 297.95 |
| WI-75WS | 489.74 | 289.85 | 118.12 | -92.59 | 309.71 |
| WI-91WS | 489.74 | 289.85 | 118.12 | -92.59 | 372.53 |
| WI-92WS | 489.74 | 289.85 | 118.12 | -92.59 | 309.74 |
| WI-93WS | 489.74 | 289.85 | 118.12 | -92.59 | 42.44 |
| WI-121WS | 489.74 | 289.85 | 118.12 | -92.59 | 53.44 |
| WI-151WS | 489.74 | 289.85 | 118.12 | -92.59 | 189.74 |
| WI-161WS | 489.74 | 289.85 | 118.12 | -92.59 | 358.34 |
| WI-162WS | 489.74 | 289.85 | 118.12 | -92.59 | 358.34 |
| WI-171WS | 489.74 | 289.85 | 118.12 | -92.59 | 322.45 |
| WI-181WS | 489.74 | 289.85 | 118.12 | -92.59 | 358.34 |
| WI-191WS | 489.74 | 289.85 | 118.12 | -92.59 | 260.77 |
| WI-192WS | 489.74 | 289.85 | 118.12 | -92.59 | 358.34 |
| WI-201WS | 489.74 | 289.85 | 118.12 | -92.59 | 147.83 |
| WI-202WS | 489.74 | 289.85 | 118.12 | -92.59 | 57.02 |
| WI-211WS | 489.74 | 289.85 | 118.12 | -92.59 | 42.86 |
| WI-221WS | 489.74 | 289.85 | 118.12 | -92.59 | 358.34 |
| WI-232WS | 489.74 | 289.85 | 118.12 | -92.59 | 182.44 |
| WI-233WS | 489.74 | 289.85 | 118.12 | -92.59 | 59.29 |
| WI-234WS | 489.74 | 289.85 | 118.12 | -92.59 | 51.21 |
| WI-235WS | Same acreage as WI-191WS. | | | | |
| WI-236WS | 489.74 | 289.85 | 118.12 | -92.59 | 319.25 |
| WI-237WS | 489.74 | 289.85 | 118.12 | -92.59 | 358.34 |
| LB-011WS | 489.74 | 289.85 | 118.12 | -92.59 | 251.67 |
| LB-041WS | 489.74 | 289.85 | 118.12 | -92.59 | 76.96 |
| LB-121WS | 489.74 | 289.85 | 118.12 | -92.59 | 327.03 |
| LB-161WS | 301.62 | 92.75 | -47.97 | -245.65 | 151.67 |
| LB-171WS | 489.74 | 289.85 | 118.12 | -92.59 | 313.98 |
| LB-172WS | 489.74 | 289.85 | 118.12 | -92.59 | 92.16 |
| LB-191WS | 301.62 | 92.75 | -47.97 | -245.65 | 284.41 |

(a) All figures are the median values today of 70 years of net returns based on a 4.6 percent real discount rate.

Note: Projects that end in WS are water spreading projects. The net present values for these proposed projects are identical in many instances. DNRC had to use generic capital cost estimates in its analysis of these projects because the conservation districts' applications did not include detailed water spreading project designs nor capital cost estimtes.

**Table L-6. Net revenues from existing and proposed irrigating operations in the Battle Creek and Milk River drainages given the proposed Battle Creek Reservior (BL-181) (a)**

| Net revenue given water is always available in the Battle Creek and Milk River drainages ($/ac) (b) | Net Revenues from Existing Irrigating Operations Given Water is Available X Years out of 10 ($/ac) (c) | | | | | |
|---|---|---|---|---|---|---|
| | 0/10 | 2/10 | 4/10 | 6/10 | 8/10 | 10/10 |
| -366.94 | -1146.52 | -722.13 | -269.02 | 191.39 | 592.25 | 1075.54 |

(a) All figures are the median values today of 70 years of net returns based on a 4.6 percent real discount rate.

(b) If water is not available under existing conditions, than supplemental water from Battle Creek Reservior is used.

(c) All figures include the fixed costs of an irrigation system over 70-year period. It should be noted that maintaining an irrigation system over a 70-year period when water is available less than 4 years in 10 would not be economically rational. The net revenues for an existing operation when water is available less than 4 years in 10 would likely be much greater if an economically rational decision was made to sell the irrigation system and revert back to a dryland operation.

**Table L-7. Net revenues from existing dryland farming/ranching operations and from the proposed irrigated operations in the Sheridan County Groundwater Area**

| Subbasin Project | Net Revenues from Proposed Irrigated Operations Given Water Availability for X Years out of 10 ($/ac) (a) | | | | Net Revenues from Existing Farm & Ranch Operations ($/ac) (a) |
|---|---|---|---|---|---|
| | 10/10 | 8/10 | 6/10 | 4/10 | |
| Sheridan County Groundwater Area | | | | | |
| 2.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 3.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 356.45 |
| 4.1 | 1243.85 | 806.94 | 437.33 | 12.84 | 358.34 |
| 4.2 | 327.70 | -22.49 | -342.71 | -680.89 | 362.26 |
| 6.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 357.35 |
| 8.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 356.39 |
| 9.1 | 276.29 | -70.44 | -384.95 | -722.42 | 348.42 |
| 9.2 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 10.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 10.2 | 1191.52 | 759.10 | 395.62 | -22.76 | 354.44 |
| 11.1 | 511.22 | 158.17 | -166.55 | -508.11 | 372.53 |
| 11.2 | 668.04 | 305.19 | -19.53 | -361.09 | 360.99 |
| 11.3 | 609.24 | 256.18 | -68.53 | -410.10 | 358.80 |
| 11.4 | 1230.31 | 790.72 | 417.02 | -13.41 | 358.34 |
| 11.5 | 315.19 | -37.86 | -362.58 | -704.14 | 372.53 |
| 11.6 | 1230.31 | 790.72 | 417.02 | -13.41 | 362.36 |
| 14.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 349.15 |
| 14.2 | 1191.52 | 759.10 | 395.62 | -22.76 | 356.26 |
| 14.3 | 365.08 | 12.59 | -311.23 | -651.73 | 358.34 |
| 14.4 | 365.08 | 12.59 | -311.23 | -651.73 | 347.29 |
| 14.5 | 472.32 | 125.59 | -188.92 | -526.39 | 358.34 |
| 14.6 | 570.34 | 223.60 | -90.90 | -428.37 | 358.34 |
| 14.7 | 1191.52 | 759.10 | 395.62 | -22.76 | 345.14 |
| 14.8 | 1191.52 | 759.10 | 395.62 | -22.76 | 340.78 |
| 14.9 | 1191.52 | 759.10 | 395.62 | -22.76 | 309.32 |
| 15.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 361.29 |
| 15.2 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 15.3 | 1168.14 | 743.40 | 387.79 | -22.05 | 356.41 |
| 17.1 | 374.31 | 27.57 | -286.93 | -624.40 | 358.34 |
| 17.2 | 276.29 | -70.44 | -384.95 | -722.42 | 355.74 |
| 18.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 356.65 |
| 18.2 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 19.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 360.55 |
| 19.2 | 1191.52 | 759.10 | 395.62 | -22.76 | 372.53 |
| 20.1 | 472.32 | 125.59 | -188.92 | -526.39 | 356.26 |
| 20.2 | 629.14 | 272.61 | -41.90 | -379.37 | 356.44 |
| 20.3 | 1191.52 | 759.10 | 395.62 | -22.76 | 347.78 |
| 21.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 21.2 | 472.32 | 125.59 | -188.92 | -526.39 | 358.34 |
| 21.3 | 1191.52 | 759.10 | 395.62 | -22.76 | 362.68 |
| 22.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 354.83 |
| 22.2 | 1168.14 | 743.40 | 387.79 | -22.05 | 349.88 |
| 22.5 | NA | NA | NA | NA | INF |
| 23.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 346.08 |
| 23.2 | 276.29 | -70.44 | -384.95 | -722.42 | 358.34 |
| 23.3 | 276.29 | -70.44 | -384.95 | -722.42 | 358.34 |
| 23.4 | 1191.52 | 759.10 | 395.62 | -22.76 | 353.27 |
| 23.5 | 1191.52 | 759.10 | 395.62 | -22.76 | 349.92 |
| 26.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 372.53 |
| 28.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 350.71 |
| 28.2 | 1168.14 | 743.40 | 387.79 | -22.05 | 354.28 |
| 28.3 | 1168.14 | 743.40 | 387.79 | -22.05 | 342.31 |

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|---|---|---|---|---|---|
| 30.1 | 719.77 | 369.58 | 49.36 | -288.82 | 344.03 |
| 30.2 | 1243.85 | 806.94 | 437.33 | 12.84 | 350.22 |
| 30.3 | 1243.85 | 806.94 | 437.33 | 12.84 | 358.34 |
| 30.4 | 1243.85 | 806.94 | 437.33 | 12.84 | 350.22 |
| 30.5 | 1243.85 | 806.94 | 437.33 | 12.84 | 356.39 |
| 30.6 | 1243.85 | 806.94 | 437.33 | 12.84 | 352.49 |
| 30.7 | 1243.85 | 806.94 | 437.33 | 12.84 | 358.34 |
| 30.8 | 1243.85 | 806.94 | 437.33 | 12.84 | 358.34 |
| 30.9 | 1243.85 | 806.94 | 437.33 | 12.84 | 358.34 |
| 30.1 | 680.56 | 320.57 | 0.35 | -337.83 | 358.34 |
| 32.1 | 252.69 | -88.88 | -393.95 | -725.89 | 339.42 |
| 32.2 | 252.69 | -88.88 | -393.95 | -725.89 | 337.29 |
| 32.3 | 252.69 | -88.88 | -393.95 | -725.89 | 347.92 |
| 33.1 | 644.76 | 303.19 | -1.88 | -333.82 | 358.34 |
| 34.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 370.62 |
| 34.2 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 34.3 | 1168.14 | 743.40 | 387.79 | -22.05 | 340.78 |
| 35.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 36.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 356.39 |
| 37.1 | 252.69 | -88.88 | -393.95 | -725.89 | 367.21 |
| 38.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 356.65 |
| 38.2 | 1191.52 | 759.10 | 395.62 | -22.76 | 356.39 |
| 38.3 | 276.29 | -70.44 | -384.95 | -722.42 | 364.29 |
| 39.1 | 276.29 | -70.44 | -384.95 | -722.42 | 316.73 |
| 39.2 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 39.3 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 39.4 | 1168.14 | 743.40 | 387.79 | -22.05 | 356.39 |
| 39.5 | 1168.14 | 743.40 | 387.79 | -22.05 | 350.33 |
| 39.6 | 1191.52 | 759.10 | 395.62 | -22.76 | 338.71 |
| 40.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 353.27 |
| 40.2 | 1191.52 | 759.10 | 395.62 | -22.76 | 349.42 |
| 40.3 | 1168.14 | 743.40 | 387.79 | -22.05 | 359.78 |
| 40.4 | 276.29 | -70.44 | -384.95 | -722.42 | 322.11 |
| 42.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 42.2 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 42.3 | 1168.14 | 743.40 | 387.79 | -22.05 | 356.45 |
| 42.4 | 546.74 | 205.17 | -99.90 | -431.84 | 372.53 |
| 42.5 | 644.76 | 303.19 | -1.88 | -333.82 | 358.34 |
| 44.1 | 1243.85 | 806.94 | 437.33 | 12.84 | 358.34 |
| 44.2 | 1243.85 | 806.94 | 437.33 | 12.84 | 358.34 |
| 44.3 | 719.77 | 369.58 | 49.36 | -288.82 | 360.31 |
| 45.1 | 719.77 | 369.58 | 49.36 | -288.82 | 305.45 |
| 45.2 | 1243.85 | 806.94 | 437.33 | 12.84 | 358.34 |
| 45.3 | 1243.85 | 806.94 | 437.33 | 12.84 | 1228.71 |
| 47.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 365.43 |
| 47.2 | 1168.14 | 743.40 | 387.79 | -22.05 | 368.96 |
| 47.3 | 252.69 | -88.88 | -393.95 | -725.89 | 358.34 |
| 47.4 | 252.69 | -88.88 | -393.95 | -725.89 | 369.10 |
| 47.5 | 252.69 | -88.88 | -393.95 | -725.89 | 370.24 |
| 54.1 | 276.29 | -70.44 | -384.95 | -722.42 | 358.34 |
| 57.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 356.39 |
| 58.1 | 1230.31 | 790.72 | 417.02 | -13.41 | 344.68 |
| 59.1 | 1243.85 | 806.94 | 437.33 | 12.84 | 356.66 |
| 59.2 | 327.70 | -22.49 | -342.71 | -680.89 | 358.34 |
| 59.3 | 1243.85 | 806.94 | 437.33 | 12.84 | 358.34 |
| 59.4 | 1243.85 | 806.94 | 437.33 | 12.84 | 1236.41 |
| 59.5 | 327.70 | -22.49 | -342.71 | -680.89 | 362.20 |
| 59.6 | 1243.85 | 806.94 | 437.33 | 12.84 | 372.53 |
| 59.9 | NA | NA | NA | NA | INF |
| 62.1 | 276.29 | -70.44 | -384.95 | -722.42 | 372.53 |
| 62.2 | 1191.52 | 759.10 | 395.62 | -22.76 | 352.72 |

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| 62.3 | 1191.52 | 759.10 | 395.62 | -22.76 | 340.07 |
| 62.4 | 1191.52 | 759.10 | 395.62 | -22.76 | 338.83 |
| 62.5 | 668.35 | 321.62 | 7.11 | -330.36 | 353.53 |
| 62.6 | 668.35 | 321.62 | 7.11 | -330.36 | 358.34 |
| 63.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 64.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 64.2 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 64.3 | 1168.14 | 743.40 | 387.79 | -22.05 | 352.49 |
| 67.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 68.1 | 1055.33 | 630.59 | 274.98 | -134.86 | 358.34 |
| 68.2 | 707.25 | 354.20 | 29.48 | -312.08 | 358.34 |
| 68.3 | 1230.31 | 790.72 | 417.02 | -13.41 | 356.52 |
| 71.1 | 425.72 | 75.53 | -244.69 | -582.87 | 358.34 |
| 71.2 | 523.74 | 173.54 | -146.68 | -484.86 | 358.34 |
| 73.1 | 276.29 | -70.44 | -384.95 | -722.42 | 358.34 |
| 73.2 | 276.29 | -70.44 | -384.95 | -722.42 | 342.91 |
| 73.3 | 276.29 | -70.44 | -384.95 | -722.42 | 358.67 |
| 75.1 | 1243.85 | 806.94 | 437.33 | 12.84 | 358.34 |
| 75.2 | 1243.85 | 806.94 | 437.33 | 12.84 | 354.44 |
| 75.3 | 1243.85 | 806.94 | 437.33 | 12.84 | 358.34 |
| 75.4 | 621.75 | 271.56 | -48.66 | -386.84 | 351.89 |
| 77.1 | 1230.31 | 790.72 | 417.02 | -13.41 | 358.34 |
| 78.1 | 707.25 | 354.20 | 29.48 | -312.08 | 333.93 |
| 78.2 | 1230.31 | 790.72 | 417.02 | -13.41 | 365.88 |
| 78.3 | 1168.14 | 743.40 | 387.79 | -22.05 | 354.57 |
| 81.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 81.2 | 1168.14 | 743.40 | 387.79 | -22.05 | 353.27 |
| 81.3 | 1168.14 | 743.40 | 387.79 | -22.05 | 355.97 |
| 81.4 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 81.5 | 252.69 | -88.88 | -393.95 | -725.89 | 349.81 |
| 82.1 | 644.76 | 303.19 | -1.88 | -333.82 | 358.34 |
| 82.2 | 644.76 | 303.19 | -1.88 | -333.82 | 356.46 |
| 82.3 | 1191.52 | 759.10 | 395.62 | -22.76 | 346.63 |
| 83.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 346.63 |
| 84.1 | 252.69 | -88.88 | -393.95 | -725.89 | 356.17 |
| 84.2 | 644.76 | 303.19 | -1.88 | -333.82 | 353.49 |
| 85.1 | 252.69 | -88.88 | -393.95 | -725.89 | 352.24 |
| 85.2 | 252.69 | -88.88 | -393.95 | -725.89 | 349.29 |
| 85.3 | 252.69 | -88.88 | -393.95 | -725.89 | 372.53 |
| 85.4 | 252.69 | -88.88 | -393.95 | -725.89 | 358.34 |
| 85.5 | 1168.14 | 743.40 | 387.79 | -22.05 | 356.57 |
| 85.6 | 1168.14 | 743.40 | 387.79 | -22.05 | 349.48 |
| 85.7 | 1168.14 | 743.40 | 387.79 | -22.05 | 353.27 |
| 85.8 | 252.69 | -88.88 | -393.95 | -725.89 | 336.02 |
| 85.9 | 1168.14 | 743.40 | 387.79 | -22.05 | 334.66 |
| 85.1 | 252.69 | -88.88 | -393.95 | -725.89 | 363.07 |
| 85.11 | 252.69 | -88.88 | -393.95 | -725.89 | 372.53 |
| 85.12 | 252.69 | -88.88 | -393.95 | -725.89 | 372.53 |
| 85.13 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 86.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 312.57 |
| 87.1 | 276.29 | -70.44 | -384.95 | -722.42 | 358.34 |
| 87.2 | 276.29 | -70.44 | -384.95 | -722.42 | 358.34 |
| 88.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 356.65 |
| 88.2 | 276.29 | -70.44 | -384.95 | -722.42 | 339.40 |
| 88.3 | 1191.52 | 759.10 | 395.62 | -22.76 | 352.88 |
| 89.1 | 276.29 | -70.44 | -384.95 | -722.42 | 356.76 |
| 89.2 | 276.29 | -70.44 | -384.95 | -722.42 | 354.33 |
| 90.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 355.28 |
| 90.2 | 1191.52 | 759.10 | 395.62 | -22.76 | 344.29 |
| 90.3 | 1191.52 | 759.10 | 395.62 | -22.76 | 361.38 |
| 90.4 | 1191.52 | 759.10 | 395.62 | -22.76 | 357.57 |

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| 90.5 | 1191.52 | 759.10 | 395.62 | -22.76 | 348.58 |
| 90.6 | 276.29 | -70.44 | -384.95 | -722.42 | 362.16 |
| 90.7 | 1191.52 | 759.10 | 395.62 | -22.76 | 343.77 |
| 92.1 | 252.69 | -88.88 | -393.95 | -725.89 | 342.71 |
| 94.1 | 276.29 | -70.44 | -384.95 | -722.42 | 354.27 |
| 94.2 | 252.69 | -88.88 | -393.95 | -725.89 | 358.34 |
| 94.3 | 252.69 | -88.88 | -393.95 | -725.89 | 353.60 |
| 94.4 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 100.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 100.2 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 100.3 | 1168.14 | 743.40 | 387.79 | -22.05 | 356.39 |
| 100.4 | 644.76 | 303.19 | -1.88 | -333.82 | 358.34 |
| 100.5 | 644.76 | 303.19 | -1.88 | -333.82 | 342.03 |
| 103.1 | 1230.31 | 790.72 | 417.02 | -13.41 | 358.34 |
| 103.2 | 315.19 | -37.86 | -362.58 | -704.14 | 357.05 |
| 104.1 | 276.29 | -70.44 | -384.95 | -722.42 | 352.76 |
| 105.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 354.96 |
| 105.2 | 276.29 | -70.44 | -384.95 | -722.42 | 358.34 |
| 105.3 | 1168.14 | 743.40 | 387.79 | -22.05 | 356.65 |
| 105.4 | 374.31 | 27.57 | -286.93 | -624.40 | 358.34 |
| 105.5 | 1191.52 | 759.10 | 395.62 | -22.76 | 354.57 |
| 105.6 | 668.35 | 321.62 | 7.11 | -330.36 | 335.80 |
| 106.1 | 276.29 | -70.44 | -384.95 | -722.42 | 364.68 |
| 106.2 | 276.29 | -70.44 | -384.95 | -722.42 | 347.71 |
| 106.3 | 374.31 | 27.57 | -286.93 | -624.40 | 344.35 |
| 108.1 | 1282.29 | 843.44 | 470.09 | 40.83 | 299.15 |
| 110.1 | 1282.29 | 843.44 | 470.09 | 40.83 | 341.43 |
| 112.1 | 1243.85 | 806.94 | 437.33 | 12.84 | 358.34 |
| 112.2 | 680.56 | 320.57 | 0.35 | -337.83 | 358.34 |
| 112.3 | 523.74 | 173.54 | -146.68 | -484.86 | 358.34 |
| 115.1 | 374.31 | 27.57 | -286.93 | -624.40 | 360.23 |
| 116.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 359.72 |
| 116.2 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 116.3 | 448.73 | 107.15 | -197.91 | -529.86 | 358.34 |
| 116.4 | 252.69 | -88.88 | -393.95 | -725.89 | 358.34 |
| 118.1 | 609.24 | 256.18 | -68.53 | -410.10 | 359.08 |
| 118.2 | 315.19 | -37.86 | -362.58 | -704.14 | 366.38 |
| 118.3 | 1230.31 | 790.72 | 417.02 | -13.41 | 361.95 |
| 122.1 | 1282.29 | 843.44 | 470.09 | 40.83 | 358.34 |
| 122.2 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 123.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.63 |
| 123.2 | 1191.52 | 759.10 | 395.62 | -22.76 | 350.65 |
| 124.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 124.2 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 124.3 | 1282.29 | 843.44 | 470.09 | 40.83 | 358.34 |
| 124.4 | 1282.29 | 843.44 | 470.09 | 40.83 | 358.34 |
| 127.1 | 315.19 | -37.86 | -362.58 | -704.14 | 358.34 |
| 127.2 | 315.19 | -37.86 | -362.58 | -704.14 | 353.93 |
| 129.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 356.35 |
| 129.2 | 511.53 | 174.60 | -139.91 | -477.38 | 348.18 |
| 129.3 | 668.35 | 321.62 | 7.11 | -330.36 | 358.34 |
| 130.1 | 413.20 | 60.16 | -264.56 | -606.12 | 354.61 |
| 130.2 | 315.19 | -37.86 | -362.58 | -704.14 | 356.71 |
| 130.3 | 1230.31 | 790.72 | 417.02 | -13.41 | 358.34 |
| 130.4 | 609.24 | 256.18 | -68.53 | -410.10 | 358.34 |
| 131.1 | 1230.31 | 790.72 | 417.02 | -13.41 | 338.05 |
| 131.2 | 707.25 | 354.20 | 29.48 | -312.08 | 355.99 |
| 133.1 | 1230.31 | 790.72 | 417.02 | -13.41 | 335.19 |
| 133.2 | 1230.31 | 790.72 | 417.02 | -13.41 | 354.25 |
| 133.3 | 1230.31 | 790.72 | 417.02 | -13.41 | 356.38 |

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| 134.1 | 252.69 | -88.88 | -393.95 | -725.89 | 359.56 |
| 134.2 | 252.69 | -88.88 | -393.95 | -725.89 | 358.34 |
| 134.3 | 252.69 | -88.88 | -393.95 | -725.89 | 360.69 |
| 134.4 | 1168.14 | 743.40 | 387.79 | -22.05 | 358.34 |
| 135.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 135.2 | 472.32 | 125.59 | -188.92 | -526.39 | 328.20 |
| 135.3 | 276.29 | -70.44 | -384.95 | -722.42 | 358.34 |
| 135.4 | 1282.29 | 843.44 | 470.09 | 40.83 | 354.96 |
| 135.5 | 1282.29 | 843.44 | 470.09 | 40.83 | 354.54 |
| 135.6 | 413.20 | 60.16 | -264.56 | -606.12 | 335.80 |
| 137.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 1191.52 |
| 138.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 355.08 |
| 138.2 | 1191.52 | 759.10 | 395.62 | -22.76 | 344.81 |
| 138.3 | 374.31 | 27.57 | -286.93 | -624.40 | 358.19 |
| 143.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 354.44 |
| 143.2 | 1168.14 | 743.40 | 387.79 | -22.05 | 354.33 |
| 143.3 | 1168.14 | 743.40 | 387.79 | -22.05 | 344.81 |
| 144.1 | 546.74 | 205.17 | -99.90 | -431.84 | 358.34 |
| 145.1 | 472.32 | 125.59 | -188.92 | -526.39 | 358.34 |
| 145.2 | 472.32 | 125.59 | -188.92 | -526.39 | 338.90 |
| 145.3 | 668.35 | 321.62 | 7.11 | -330.36 | 356.16 |
| 146.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 146.2 | 570.34 | 223.60 | -90.90 | -428.37 | 358.34 |
| 147.1 | 276.29 | -70.44 | -384.95 | -722.42 | 372.53 |
| 148.1 | 1230.31 | 790.72 | 417.02 | -13.41 | 339.25 |
| 148.2 | 1230.31 | 790.72 | 417.02 | -13.41 | 354.83 |
| 148.3 | 1230.31 | 790.72 | 417.02 | -13.41 | 333.70 |
| 150.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 356.28 |
| 150.2 | 605.55 | 254.18 | -50.89 | -382.83 | 358.34 |
| 151.1 | 1168.14 | 743.40 | 387.79 | -22.05 | 356.65 |
| 151.2 | 1168.14 | 743.40 | 387.79 | -22.05 | 354.96 |
| 152.1 | 365.08 | 12.59 | -311.23 | -651.73 | 280.21 |
| 155.1 | 1243.85 | 806.94 | 437.33 | 12.84 | 372.53 |
| 156.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 156.2 | 276.29 | -70.44 | -384.95 | -722.42 | 358.34 |
| 156.3 | 365.08 | 12.59 | -311.23 | -651.73 | 351.83 |
| 157.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 356.38 |
| 157.2 | 570.34 | 223.60 | -90.90 | -428.37 | 310.76 |
| 159.1 | 425.72 | 75.53 | -244.69 | -582.87 | 358.34 |
| 160.1 | 707.25 | 354.20 | 29.48 | -312.08 | 358.34 |
| 161.1 | 605.55 | 254.18 | -50.89 | -382.83 | 358.34 |
| 161.2 | 605.55 | 254.18 | -50.89 | -382.83 | 350.93 |
| 162.1 | 365.08 | 12.59 | -311.23 | -651.73 | 358.34 |
| 163.1 | 327.70 | -22.49 | -342.71 | -680.89 | 362.06 |
| 163.2 | 719.77 | 369.58 | 49.36 | -288.82 | 324.94 |
| 164.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 356.74 |
| 165.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 356.15 |
| 165.2 | 1191.52 | 759.10 | 395.62 | -22.76 | 353.50 |
| 166.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 166.2 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 168.1 | 1230.31 | 790.72 | 417.02 | -13.41 | 358.34 |
| 170.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 357.82 |
| 170.2 | 1191.52 | 759.10 | 395.62 | -22.76 | 350.16 |
| 171.1 | 707.25 | 354.20 | 29.48 | -312.08 | 358.34 |
| 171.2 | 707.25 | 354.20 | 29.48 | -312.08 | 352.42 |
| 176.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 177.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 353.81 |
| 179.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 179.2 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |

| | | | | | |
|---|---|---|---|---|---|
| 179.3 | 1282.29 | 843.44 | 470.09 | 40.83 | 358.34 |
| 179.4 | 1282.29 | 843.44 | 470.09 | 40.83 | 338.05 |
| 179.5 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 179.6 | 1282.29 | 843.44 | 470.09 | 40.83 | 358.34 |
| 179.7 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 179.8 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 179.9 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 179.1 | 1282.29 | 843.44 | 470.09 | 40.83 | 358.34 |
| 179.11 | 1282.29 | 843.44 | 470.09 | 40.83 | 358.34 |
| 179.12 | 1282.29 | 843.44 | 470.09 | 40.83 | 358.34 |
| 179.13 | 1282.29 | 843.44 | 470.09 | 40.83 | 356.65 |
| 179.14 | 1191.52 | 759.10 | 395.62 | -22.76 | 356.65 |
| 179.15 | 276.29 | -70.44 | -384.95 | -722.42 | 358.34 |
| 180.1 | 1191.52 | 759.10 | 395.62 | -22.76 | 358.34 |
| 180.2 | 629.14 | 272.61 | -41.90 | -379.37 | 358.85 |

(a) All figures are the median values today of 70 years of net returns based on a 4.6 percent real discount rate.

Note: The net present values for these proposed projects are identical in many instances. DNRC had to use generic capital cost estimates in its analysis of these projects since the conservation district's application did not include detailed project designs nor project specific capital cost estimates.

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# APPROXIMATE WATER EQUIVALENTS

1 cubic foot = 7.48 gallons

1 acre-foot (af) = 43,560 cubic feet, or 325,851 gallons
An acre-foot covers one acre of land one foot deep

1 cubic foot per second (cfs) = 448.8 gallons per minute

1 cfs = 40 Montana statutory miner's inches

1 cfs = 646,316 gallons per day
for 24 hours = 1.98 acre-feet
for 30 days = 59.5 acre-feet
for 1 year = 725 acre-feet

1 million gallons = 3.07 acre-feet

1 million gallons per day (mgd) = 1,122 acre-feet per year

1,000 gallons per minute (gpm) = 2.23 cfs

1,000 gpm = 4.42 acre-feet per day

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